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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXIII, No. 8 NOVEMBER, 1923 WHOLE No. 199

THE PSYCHOLOGY UNDERLYING INSTRUCTION IN CHEMISTRY.

A. E. BROWN and W. G. BOWERS, COLORADO STATE TEACHERS COLLEGE, GREELEY, COLO.

The field of chemistry is one that has not received any very elaborate or specific treatment at the hands of the educational psychologist. This is our justification for offering such contribution to the psychology of the subject as may be found in this article. We are not so much suggesting wholly new methods of presenting chemistry as we are suggesting psychological bases and explanations for the various phases of chemical instruction.

One of the first questions that should receive the consideration of the chemistry instructor is the place to be given in his instruction to the direct or discovery method. Shall we in teaching chemistry have the student re-live the racial development in discovering and solving chemical problems? When we state the question in this extreme form we at once see the impracticability in the direct experience plan. We cannot allow a student to squander time in making mistakes long ago rectified; in pursuing false theories; in developing through his own efforts a technique already known and fairly well standardized. To do so is to be too wasteful of his time and effort. The student has a right to get his mastery of chemistry as economically as possible. While there must be some discovery and some direct attack, it must be discovery in certain limited and selected fields, where it can be shown to develop the student's confidence in his ability to proceed alone in chemical matters, and to give an improved appreciation and better understanding of scientific method.

The contrast between the method of discovery and the usual method is the difference, as Smith has shown us, between conferring ability and conferring knowledge.[1] We want the student

[1] Smith & Hall—Teaching Chemistry & Physics, p. 107.

to have both; but the attempt to confer ability must not consume an inordinate amount of time; nor must it be allowed to defeat the end of securing a fairly well rounded body of information about the main principles and values of chemistry.

The question of what are the most favorable mental states on the part of the student for successful work in chemistry is one which must engage the attention of the instructor who is interested in securing good results. To that question we now turn for a brief discussion.

If the student comes to the chemistry course with his original tendencies properly developed, he will have one attribute that is among the teacher's strong allies. This is the instinct of curiosity. We must not make the mistake, however, of supposing that since the pupil is supplied with this instinct that its proper employment is not a matter of requiring the careful and judicious attention of the teacher. As with most instincts the situation must be properly selected and set up to cause the instinct of curiosity to awaken in such a way as to produce educational returns. How is this to be done? Gordon suggests that all work be thrown into the problem form; avoiding using problems that have been discussed over and over again in a book and in the lecture.[2] In other words, it is advised that we create a "forked road situation," as Dewey calls it. Arrange a problematical situation whose outcome the pupil feels he must know. Then leave some things for the student to find out, when you are first of all sure that he wants to find them out.

In passing from this phase of the subject it may be said that there will develop a science of teaching chemistry just as soon as teachers of chemistry learn how to use this and other native tendencies, and interests of the students.

A second important matter in securing a favorable frame of mind is to remove from the pupil's consciousness vague and needless fears. To allay such fears is a part of the task of the efficient chemistry teacher. Before reaching the laboratory students hear of explosions which have occurred; of burns received and other accidents or near-accidents. Only the more fearless and intrepid can ignore this mixture of knowledge and rumor. How is the teacher to counteract these unfavorable tendencies? First of all, the student must develop a feeling of personal confidence in the instructor and in his intention and ability to see that needless accidents do not occur. This will secure the proper initial

[2]Gordon: Science, Vol. 54:656.

attitude. To make this permanent the teacher must arrange work so that the early expectations of safety are realized. To do this, avoid the study of hydrogen and its properties as an initial topic. Familiar solids or liquids may be preferable for early study as being less dangerous.

Not only should we develop curiosity and allay fears but we must develop a growing confidence in the student's ability to discover and interpret. Some of the abstractions which to the expert chemist are rather concrete and familiar are to the student vague, confusing and unreal. If his reactions to these ideas are faulty or inadequate, the instructor must be patient. The least semblance of an original idea should be encouraged in the student and be made the basis for future progress. In a similar way the instructor should watch carefully the attempts of the student to develop his own attack upon a problem. Allow him to proceed alone as long as he feels that he can do so. Check him, however, in the pursuit of erroneous theories or in the use of faulty technique before his attempt becomes too wasteful or discouraging.

We have referred to certain desirable mental states in chemistry instruction. More specifically, upon what types of thought processes does successful work in chemistry depend? What are the specific things that we do in getting the job done? Smith, who has given us a very well balanced and careful discussion of chemistry teaching points out that there are three main items in the technique of instruction.[3] These are: Observation, Generalization, and Application. In what we have to say about these topics we are not so much concerned with the evaluation of the particular formulation given as we are in the working out in the mental processes which occur in the employment of each of them.

As a subject of the laboratory type, chemistry is unlike the discursive subjects. The materials used are in the main concrete; the phenomena studied present certain observable features. The observations which the student makes of the materials and phenomena before him, it is usually assumed, will be productive of large educational returns. We find so very often that the expectations of the amateur teacher for returns from this source are not fully realized. What causes this "slip twixt the cup and the lip"? It is commonly due to faulty practice growing out of a misconception of the nature of observation. The matter of observation is not of the simple automatic type which it is often

[3]Smith & Hall: Teaching Chemistry & Physics—

supposed to be. If the student is to profit by his observations, there must be something more to the process than the mere piling up of pure observational data, or mere "ocular accuracy" in seeing what is presented to the senses. Approaching the matter from a more positive direction, we may say that effective observation consists in "storing the mind with suitable experience, all thoroughly classified and digested."[4] The chemist does not simply state at his apparatus; he does not content himself even with the recognition of certain facts as they appear; such as the lustre of certain metal, the odor of a certain acid, and the like. The chemist in his observations is active. He combines facts recognized in the experiment with ideas stored in memory. Now the student, like the chemist, must explore and must manipulate ideas. "Observation is to be discriminated from recognition, or perception of what is familiar."[5] As contrasted with identification, observation is searching and deliberate, while identification is automatic and passive.

If we go the full length with Dewey in his conception of observation, we find other "refinements" in the process. The use of these "refinements" plunges their user almost at once in the processes of reflective thought. The observer would, according to Dewey,[6] (1) find out what sort of perplexity confronts him; (2) infer hypothetical explanations; and (3) test the ideas presented. We do not care to load the term observation with quite so much freightage. The main point which we do wish to emphasize is that the observer who gets results is self-active; he actively explores, often selecting items for special scrutiny. He is not merely a photographic plate to catch a record of appearances and phenomena. The student in observing the behavior of an acid (say HCl) and a metal, will let his mind play with the data which appears to his senses, relating it possibly to data produced from his memory.

Not only must the observer be self-active or in other words an explorer, but he must be interested in phenomena that are devoid of spectacular features. The spectacular in chemistry may be of second-rate importance, while on the other hand some unobtrusive feature of the phenomena may be the key which will unlock the deeper meaning. As this matter is developed more

[4]Smith & Hall, p. 87.
[5]Dewey, How We Think, p. 193.
[6]Dewey, How We Think, p. 196.

fully in our considerations of the scientific imagination we need not linger longer with it at this point.

A second phase of techinque is the process of generalization. The generalization is something toward which we must constantly work as we accumulate experimental data. The student who has worked through a series of experiments dealing with the displacement of hydrogen should want a generalization which will allow his mental processes momentary pause. It should be noted, however, that this particular data which the student wishes to get away from, is a very indispensable pre-requisite to reaching a generalization. We cannot generalize out of nothing; we must have data.

According to Dewey, the process of generalization depends upon three factors.[7] In the first place, one must eliminate by analysis what is likely to be misleading or irrelevant. Thus, a student inquiring into the various phases of oxidation must beware of by-paths suggested by associated but irrelevant data. The student might, for example, fix upon the appearance of the flame as the essential fact. The second element in generalization, says Dewey, is the appearance of the important element through the collection and comparison of cases. Again employing the example of oxidation; important data are found in the unlikeness of what is found in the burning coal as compared with the rusting of iron. The dissimilarity of the visual aspects of the two cases brings out the fact that something other than the observed manifestations of heat, flame, accumulation of a red deposit, etc., are the essentials of the situation. "The object of bringing into consideration a multitude of cases is to facilitate the selection of the evidential or significant features upon which to base inference in some single case."[8]

The third element in successful generalization, as developed by Dewey, is the deliberate construction of data by experimental variation. Dewey seems to refer to a type of rather expert chemical technique which is beyond the ability of the average high school student. We do not, therefore, take time to discuss it.

The ultimate goal of the teaching act is the process of effective application. The alert and inquiring mind will not rest at ease until the tedious process of discovery and generalization moves on to application. Woodhull[9] gives us three reasons why we

[7]Dewey, How We Think, p. 89.
[8]Ibid, p. 89.
[9]Woodhull, Teaching of Science, p. 43-44.

should always teach the principle with reference to its application. Two of these reasons are here stated: (1) Our pupils get no correct appreciation of the principles themselves until they see their applications. A subject becomes a science only when its principles are related to something. (2) The subject must be taught with reference to its practical application not only for commercial purposes but for the sake of human culture."

Smith[10] gives us a number of clear examples of application. The laws of the conservation of matter may be illustrated in the results of raising the same crops on the same piece of land year after year. The law of definite proportions may be applied to the heating of our houses; were it not for this law we could not regulate the heating of our houses, as there would be irregularity of combustion. The absence of such a law would also make it impossible to contract for a supply of iron, since manufacturers could not foretell what quantity of coal would be necessary for the reduction of ore. These are doubtless more picturesque examples than one would ordinarily hope to find; but they give some clue as to what the alert teacher may expect to do in assisting his students toward practical applications.

Two other considerations relative to application may be discussed. The first of these pertains to a certain interplay between generalization and application. Application cannot occur of the pupil's own initiative unless there is already a fair understanding of the generalization—that is, unless the pupil has done his own generalizing. Otherwise stated, careful and inteligent generalizing is a pre-requisite to application. The pupil cannot apply the principles which should be apparent from the distillation of water, to the matter of the distillation of crude oil into its various products, if he has not carefully thought out the first process. But we often find that there is action in the other direction also. The application may serve to clarify the generalization. The student who makes the application of the law of conservation of energy to soil conservation doubtless has a much better hold on the law than the individual who does not develop some application.

The other consideration relative to application which we desire to present is the matter of the locus or the direction of application. It is customary to think of application always as occurring out from the subject to another more or less distinct field. Judd[11] has called attention to another type of application. In

[10]Smith & Hall, pp. 129-130.
[11]Judd, Psychology of High School Subjects, pp. 450-452.

this type of application, the student applies the material mastered by looking forward to its subsequent use within the limits of the subject itself. This, it seems to the writer, is a valuable form of application. Let the student see what leads there are from a given generalization to other principles or facts. Let there be application in a straight line through the subject as well as in right-angled transitions to other subjects.

We have already discussed three of the fundamental items in the procedure of teaching chemistry. We refer to observation, generalization, and application. We have made no mention of the use of symbolism, which is a much used implement in the management of chemical learning. To that we now turn. What is the proper use of symbolism? How is it mastered? Just how far one could proceed in chemical studies without a mastery of symbolism, we do not know; we should naturally expect that the progress of the individual would suffer a check before he had advanced far into the subject. If we may assume, as it seems entirely safe to do, that the better understanding of the more elementary chemical processes and success in any degree in the more involved phases of the subject both depend upon the use and understanding of symbolism, then how should the matter be managed? For one thing, we may be sure that the use of concrete material must precede the adoption of symbolism as a system of describing substances or their behavior. The individual will have to be initiated into the matter in such a way that he is not suddenly lifted, through the use of symbols, from his familiar mental terra firma. The concepts of element, compound, subscript, the use of the equal sign or the arrow in the equation must be made as clear as possible before the student abandons the elaborate verbal description for the empty and abstract looking symbols. The student must be inducted not suddenly but gradually, into the notion of symbolism that it provides him with a sort of shorthand which will simplify the account of what is occurring in one experiment. It will gradually dawn upon him that he can rid himself, through the use of symbols, of many cluttering details which are irrelevant to the essence of the matter before him.

Much of the difficulty commonly assigned to the use and understanding of symbolism, is not due to the inherent difficulty of the symbols themselves, but rather to the complexity and the abstractness of the facts themselves. Thus in the equation

$$2NH_4+Ca(OH)_2-CaCl_2+2NH_4OH$$

the difficulty relates to such matters as to why we have two molecules of the first compound; as to why we have the subscript 2 in the symbol for calcium hydroxide, and the like. Otherwise stated, the real difficulty lies in the proper mastery of the notions of the molecule, atom, valence, and the like, rather than in the symbols themselves. The difficulty is not in getting a symbol to stand for an idea or a relationship, but in getting the idea or relationship itself.

It has been assumed throughout our discussion that the study of chemistry should make some contribution to the development of capacity for scientific thinking. We must now inquire into the nature of the act of scientific thought, and see to what extent and in what ways high school students of chemistry may apply it.

Dewey points out that scientific thinking is characterized by two factors.[12] Take, for example, the matter of explaining how an ordinary cistern pump works. The empirical thinker would probably dismiss the matter by saying that suction is the cause. But the scientific thinker would not be satisfied so easily. His first step ordinarily would be to break up the gross fact into a number of simpler elements. He would try to vary the conditions one by one. This might be done by comparing the results of a number of observations occurring under accidentally different conditions. The height to which water could be drawn by a suction pump in different localities might be considered. But the method of depending upon accidental cases is badly handicapped; it can do nothing until it is presented with a certain number of diversified cases. The scientist, in disposing of these handicaps, may set up on a small scale experiments which vary at will the various elements in which he may be interested. He may remove the atmosphere entirely as an element in the situation; he may increase the atmospheric pressure, or reduce it. This experimental procedure, which is our first element of difference, has certain advantages: (1) it lessens liability to error; (2) the new factors become "manageable," that is, they are identified with a group of phenomena or facts with which they were not previously identified; and (3) the experiment throws into relief the future possibilities of the new discovery.

[12] Dewey, How We Think, pp. 150-156.

In chemistry the scientific mind would proceed in a somewhat similar way. Not content to stand on the unscientific assumption that wood is destroyed in the process of combustion, water in the process of evaporation, etc., the scientific mind would collect such natural occurrences, preferably dissimilar, as seemed to throw some light on the matter. And if unsatisfied with this manipulation of natural data, would then set up the machinery for more rapid and controlled observation of the phenomena.

A second feature of scientific thinking is that it is not so much impressed by the directness and intensity of forces as is the empirical thinker.[13] The primitive empirical thinker was doubtless greatly impressed by the roar of a waterfall; but it required more abstract thought to see that the water had this in common with the horse, or the mule—that it could be used to set other objects in motion. Probably the student in the laboratory does not get much experience in discovering unaided and for the first time such relationships; but he does (or at least he should) be brought constantly to see that one must often go to the less spectacular elements, to the items with less stimulating power, for the really significant data.

A third characteristic of scientific thinking is implied in the two elements just discussed. But for clarity and emphasis it needs to be isolated and discussed, as a separate characteristic. We refer now to what we call Scientific Imagination. The term will here be used to signify "re-combinations of mental processes worked out systematically and coherently.[14] Our psychology tells us that our imagination enables us to make combinations of ideas that have never actually been experienced in combinations. In imagination we play with the data supplied by nature, and recombine the ideas in varied ways. The scientists who have made the great discoveries seem to have made large use of the imagination. Kepler, so his biographer tells us,[15] was a bold "guesser." This guessing doubtless means the experimental and tentative linking together of seemingly unrelated data, to see if some productive clue cannot be derived from such combinations.

The scientist must not, however, be content to let the courageous combinations of data remain uncriticised or untested. To let the mental combinations stand without question is to indulge in phantasy or day dreaming. If the linking of the dif-

[13]Dewey, How We Think, pp. 154-155.
[14]Judd, Psychology, p. 255.
[15]Whewell, History of the Inductive Sciences, pp. 291-292.

ferent sets of ideational data does not yield up workable ideas or hypotheses, then the thinker must evolve new mental constructs.

It must not be expected that the high school student will exemplify in full the use of the scientific imagination just described. As stated earlier in this paper, he is not purely a discoverer; he is not a Tyndall or a Lavoisiner. There must be some functioning of the scientific imagination, however, some of Kepler's guessing from observed data. Over-elaborate texts and laboratory manuals do not favor this sort of functioning. The wise teacher must see that it occurs within the limit set by the pupil's capacities, and the limitations of time imposed by a body of subject-matter worthy of mastery.

A SCORE CARD FOR GENERAL SCIENCE TEXTBOOKS.

By Herbert J. Stack,

Supervisor Secondary Schools, Johnstown, Pa.

Pennsylvania has taken a distinctly forward step in her educational program for science in the Public Schools of the Commonwealth. The new state syllabus calls for a 12 year course in science largely featuring nature study in the first six grades, general science in the seventh, eighth, and ninth grades with the special sciences in the Senior High School. This has opened up a field for General Science in the Junior High School which calls for the very best of teaching and the very best of textbooks if Science is going to qualify for its most important position in the elementary and secondary school curriculum.

There is probably no subject in the Junior High School where better books are available than in General Science. With the organization of the Junior High School and the reorganization of secondary school subjects following the reports of the national committees of the N. E. A. the writers of science textbooks have been busy building up books more suited to the Junior High School point of view.

During a nine weeks' course given to General Science teachers a study was made of some fifteen of the best books on the market with a view of seeing which books were most suited to the new state syllabus in science. From this study the following score card was made up by this group of teachers and the textbooks scored and rated for adoption as basic or supplementary books. Two score sheets were kept, one for books for grades seven and eight, and another for grade nine and the unanimity of opinion

in regard to the best textbooks was surprising considering the number of books scored and number of teachers who contributed their estimates. It is altogether obvious that no longer can we justify our general science courses as elementary chemistry, physics and biology and preserve the logical, sequential organization that these special sciences have in the Senior High School and College. If science is to deal with a series of life problems the work must be so organized that all the sciences can be brought in to contribute toward the solution of the problem being considered.

The score card as it was organized follows below:

A SCORE CARD FOR GENERAL SCIENCE BOOKS

I. Correlation with Fundamental Objectives of Secondary Education. 20 points
   (a) Is the material built around Health, Citizenship, the command of Fundamental Tools, Vocation, Worthy Home Membership, Preparation for Leisure and the objectives of character building?
   (b) Does the book deal with real practical every-day experiences?

II. Adaptability to the Organized Course of Study in use in the school system. 10 points

III. Is the psychological organization of the book based upon the learning process? 10 points
   (a) Is the textbook a composite book made up of chapters on various sciences or is it a series of problems involving a number of the sciences and fields of learning?
   (b) Is it written by a teacher who has actually had experiences in the teaching of the subject to secondary school pupils?

IV. The Character of the Illustrations. 10 points
   (a) Are the illustratings clear and interesting?
   (b) Are the line drawings practical and helpful?

V. Laboratory Experiments and Project Aides. 10 points
   (a) Are there provisions for and descriptions of good experiments and projects?

VI. Helpful Suggestions as to other Sources of Material and Bibliography. 10 points

VII. Are the lessons in themselves well organized? 10 points
   (a) Do they involve (1) A felt problem; (2) A definite location; (3) Suggestions for solution; (4) Reasoning and conclusions; (5) Further observation and acceptance or rejection.
   (b) Do the problems considered follow the idea of the scientific method as explained in Bull. 26, Bureau of Education?

VIII. What is the material character of book itself? 10 points
   (a) Paper.
   (b) Binding.
   (c) Printing.
   (d) Cost.

IX. Is the book written in clear-cut, comprehensible English and the subject matter considered appropriate to the type of children who are to use it? 10 points

Total, 100 points.

ILLINOIS ACADEMY OF SCIENCES.

Minutes of May Business Meeting.

The meeting was called to order by President Bayley, at Lombard College, Galesburg. He called for the report of the Treasurer for the year 1922-23 which is as follows:

Receipts.

Balance on hand May 1, 1922	$ 629.32
Received for dues (initiation and annual)	445.10
A. A. A. S. dues collected by the Academy	1,224.85
Received for reprints	368.93
Received for transactions	34.24
	$2,702.44

Disbursements.

Paid for stationery, postage and other expenses of officers	$ 403.37
Paid printing bills	449.25
Paid to A. A. A. S. for dues collected	1,224.85
Amount refunded for excess dues, etc.	15.00
Secretary's salary	150.00
	$2,242.47
Total Receipts	$2,702.44
Total disbursements	2,242.47
Cash on hand	$459.97

The Secretary next reported on the growth of the Academy since 1908, when the Academy was organized. There were, at that time, 114 charter members. During the time that the Academy has been in existence it has shown a steady growth. During 1922 there were 546 members. Of this number 329 were members of the A. A. A. S., thirty-six were charter members, forty-nine life members, and fifty-four living outside the State of Illinois.

The Librarian reported a steady call for copies of the transactions from all parts of the country. These are being sold for $1.50 a copy. Reports of officers and committees were accepted.

Chairman Hessler, of the Committee on High School Science Clubs, stated that his committee had been working through the year, looking toward the formation of high school clubs and their affiliation with the Academy. The Committee had sent out to 621 high schools of the state an eight-page pamphlet outlining the importance of Science Clubs and suggesting methods of carrying on such clubs.

The Publication Committee reported that the transactions for the Rockford meeting had been received and copies mailed to all members.

On the motion of A. R. Crook it was voted that all papers presented at meetings must be in the hands of the Secretary within thirty days after the adjournment of the annual meeting, or they could not be published.

Business Meeting, May 5, Lambard College.

President Bayley called for the reports of Committees.

The Auditing Committee reported that the accounts of W. F. Schulz were correct.

The Nominating Committee presented the names of the following officers:

President—W. G. Waterman, Northwestern University, Evanston.

Vice President—H. J. VanCleave, University of Illinois, Urbana.

Secretary—C. Frank Phipps, State Teachers College, De Kalb.
Treasurer—W. F. Schulz, University of Illinois, Urbana.
Librarian—A. R. Crook, State Museum, Springfield.
Mention was made of the death of six members during the year.
Membership Committee for 1923-24 is as follows:
Clarence Bonnell, Township High School, Harrisburg, Chairman.
Patsy H. Lupo, Rockford College, Rockford.
W. H. Packard, Bradley Polytechnic Institute, Peoria.
Fred R. Jelliff, President Knox County Academy of Science, Galesburg.
E. E. DeTurk, University of Illinois, Urbana.
Bills in the legislature, concerning state parks and forestry, were favored. The work of the High School Science and Club Committee was approved and thanks were expressed to all who were taking part in making the Galesburg meeting a success.

C. FRANK PHIPPS, Secretary.

PACIFIC BELIES NAME, SAYS INDIANA GEOGRAPHER.

A danger sign was hung out over parts of the Pacific about which little weather information has been published when Dr. Stephen S. Visher, of Indiana University, gave members of the American Meteorological Society meeting at Los Angeles, figures on the number of hurricanes sweeping those waters.

On the average two or three violent cyclones occur annually off the west coast of Mexico and Central America, he said. There are few islands between Hawaii and Mexico, and relatively few ships passed that way before the Panama Canal was opened. Surprisingly little has been written about the storms in that region and now it is very desirable that the danger be known.

The central Pacific likewise is not without dangerous storms, Dr. Visher said, although few appear to attain the hurricane violence that is the case in the eastern and western parts of the ocean. About twenty-seven cyclonic disturbances have occurred in tropical latitudes between longitudes 140 W and 140 E in the last three years. Of these an average of three a year were accompanied by gales. Honolulu, which is reputed not to have severe storms, nevertheless suffered from a wind of fifty-six miles an hour in January of this year.—[*Science Service.*

THE PRESIDENT'S PROCLAMATION.

In order that the people of the nation may think on these things, it is desirable that there should be an annual observance of Educational Week.

Now, Therefore, I, Calvin Coolidge, President of the United States, do hereby proclaim the week beginning on the eighteenth of November, next, as National Education Week, and urge its observance throughout the country. I recommend that the state and local authorities cooperate with the civic and religious bodies to secure its most general and helpful observance, for the purpose of more liberally supporting and more effectively improving the educational facilities of our country.

In Witness Whereof, I have hereunto set my hand and caused the seal of the United States to be affixed.

Done, in the city of Washington, this twenty-sixth day of September, in the year of our Lord, One Thousand Nine Hundred Twenty-three, and of the Independence of the United States the One Hundred forty-eighth.

(Signed.) CALVIN COOLIDGE.

A GEOGRAPHIC STUDY OF THE NITRATE REGION OF CHILE.

By Clarence Post,
Glenville, West Virginia.

The republic of Chile, situated on the western coast of South America, is the most remarkable of all the states composing that great continent. In its varieties of climate, natural resources and interests of the people, it is without a parallel in the western hemisphere. Chile occupies a vast stretch of territory lying between the Andes Mountains and the Pacific Ocean. It reaches from latitude 17° 17′ S. to Cape Horn, a distance of 2,627 miles. Placed east and west across the United States, it would reach from New York City to San Francisco, and extend more than fifty miles into the Pacific Ocean. On the north, lies the republic of Peru, on the east the republics of Bolivia and Argentina, while to the south and west is the Pacific Ocean. The crest of the Andes forms the boundary line between Chile and Argentina. The width of the country varies greatly, but has an average of about seventy miles. More than 290,000 square miles are included within its borders.

The surface of the republic presents about as much variation as can well be imagined. High, towering peaks capped with snow all the year 'round contrast strangely with the broad, fertile valley of central Chile, where vegetation of all kinds is most abundant and where many kinds of flowers bloom in greatest profusion. Contrast with this the desert region to the north, where rain never falls and where there is an utter lack of vegetation of all kinds, and you have a strange, almost weird combination, such as is rarely if ever equaled.

Topographically, the country is composed of two mountain ranges, more or less parallel, separated by a somewhat irregular valley. On the west coast, and bordering the Pacific Ocean, is the coast range. This range extends southward from the northern limit of the country to about latitude 43°S. where it is replaced by a number of archipelagoes which characterize the southern part of the republic. The coast range is but the remnant of much larger mountains, which have been depressed through the long, geologic ages. This, together with the incessant work of the atmosphere for millions of years, perhaps, has shorn them of much of their ruggedness and grandeur. The strata found in these mountains are Pre-Cambrian, so that granites, gneisses and schists, with abundant proof of great disturbance of the rocks, are everywhere in evidence. At the time

these mountains were high and bold, defying the force of wind and tide, the rest of the continent was beneath sea level, save for a large island far to the eastward—the Brazilian Highlands—and another island to the north, the highlands of the Guianas.

Then there followed a very long time, for geologic changes cannot be reckoned in years, during which took place great changes wrought by the earthquake, the atmosphere and the volcano. Sediments containing gypsum, chalk and limestone were gradually accumulating until finally, near the close of the Cretaceous period, the great Andes Mountains were uplifted, leaving on each side a valley. The one to the west is of special interest to us, since it comprises the great agricultural region of central Chile, and also the vast deposits of sodium nitrate in the desert region to the north. The water in this Chilean valley must have been very deep, for the rock strata there bear fossils of animals such as live only in deep water. Transverse mountain ridges, determined largely by volcanic action, broke up the Chilean valley. Since precious metals are so often associated with volcanic activity, these regions became the places where gold and silver were found. It was the lure for these precious metals that attracted the Spaniards, south from Peru, and determined largely the early history of the republic. The valley of central Chile thus received the sedimentation from the Andes Mountains to the east and the coast range to the west. Slowly the Andes rose higher, projecting their jagged peaks skyward, while their rock strata were becoming more and more distorted. Thus was produced a barrier to the southeast trades, depriving them of their moisture and rendering the valley of northern Chile a barren waste.

In the wake of this great mountain making movement, the valley of central Chile was elevated, still receiving the sedimentation containing gypsum, limestone and sand. Especially was this true in the southern portion, where the rainfall was abundant until, with the sub-tropical climate there, the whole region became a veritable Eden. In the northern part of this valley, since no rainfall occurs there, but little stream erosion has taken place and the minerals as originally deposited out of the retreating sea water have been but little changed through the ages. Thus we have, in brief, the geologic setting for an industry unique in modern economic history—an industry such as exists nowhere else in the world and which contributes in very large measure to the well being of mankind.

Climate.

Since the republic of Chile extends over such a great range of latitude, and since it is in the path of two very distinct wind systems, it is but natural that there should be great variations of climate. For convenience of treatment, it may be thought of as composed of four climatic zones which differ greatly in temperature, rainfall and natural resources: 1. The mineral zone. 2. The mineral and agricultural zone. 3. The Agricultural zone. 4. The wooded and fishing zone.

The mineral zone extends from the northern limit of the republic, southward to Coquimbo, at latitude 30°S. It can readily be seen from a map that this zone includes about one-half the entire area of the country. This region is in the path of the southeast trades and whatever water vapor they may be carrying is deposited on the lowlands of Argentina and on the eastern slopes of the Andes. Rain seldom falls in this region and there is no vegetation to be seen. It is one of the most desolate places to be found anywhere. The diurnal range of temperature is very great, due to the low relative humidity of the air which rarely rises above thirty per cent. There is not much change of temperature with the seasons in this region, the highest temperature being reached in February and the lowest in July. Absence of rainfall means a lack of streams, so that with the exception of the Loa river, no stream enters the Pacific for a distance of six hundred miles. It is this aridity that has preserved the wonderful deposits of sodium nitrate found there.

The mineral and agricultural zone is a mountainous, thinly settled region extending from latitude 30°S. to Valparaiso at 33°S. The northern part of this region has an annual rainfall of about six inches and the amount of precipitation increases to the southward. The temperature is, on the whole, about five degrees lower and there is more seasonal variation. This is less diurnal range in temperature than in the zone to the north and the relative humidity is higher. It is a constricted part of the republic where the level land has been crowded out by the nearness of the Andes Mountains and the coast range. There is a number of small streams in this region which flow into the ocean. In the valleys of these are located many small farms. A railroad runs directly south through this zone, connecting with the one running east from Valparaiso, through the Uspallata Pass, by a tunnel two and one-half miles long. This

is the only means of transportation between Chile and Argentina.

The agricultural zone extends from Valparaiso, to the Bio Bio River, at about latitude 39°S. It contains about seventy-five thousand square miles and is the garden spot of the republic. Its rainfall is effected by the moisture-bearing westerlies and consequently there is a sufficient quantity for all kinds of agricultural purposes. The amount of precipitation ranges from twenty inches, at Valparaiso, to fifty inches at Conception. The rainfall occurs chiefly from May to September. The temperature ranges from fifty to sixty degrees, Fahrenheit which makes ideal conditions for the growing of many kinds of crops. Thus the Central Chilean valley—in many places thirty miles wide—produces vast crops of maize, barley, flax and all kinds of fruit.

The wooded and fishing region extends from the Bio Bio River to Cape Horn. The greater portion of this section of the country is broken by groups of islands across which the westerly winds often blow with great fury. The rainfall increases rapidly to the southward, so that at latitude 47°S. it averages about two hundred nineteen inches a year. It is fairly well distributed through the year and the temperature ranges from thirty-five to forty-five degrees, Fahrenheit. It is into the mountain fastnesses of this region that the Spaniards drove the sturdy Auracanian Indians in the early days, and not being able to conquer them, made a treaty with them by the conditions of which the Indians were to retain control of the lands south of the Bio Bio River. Vast virgin forests crown the mountain slopes. South of the thirty second parallel, the first glaciers are seen on the mountain tops, that extend east and west and from the forty sixth parallel, the glaciers extend almost to the shore. Rivers are numerous and they sweep down the steep slopes in torrents.

The Chilean city of Punta Arenas, facing the Strait of Magellan, is the most southern city in the world. Before the completion of the Panama canal it enjoyed a unique position, since it was the chief port between Bahia Blanca, on the east coast of South America, and Talcuhano on the west. Sheep farming is the chief occupation of the people of that section.

Natural Resources.

The natural resources of this wonderful country are so numerous and varied that the limits of this paper will allow but a brief mention of them. The mineral zone is the richest in

mineral deposits, being especially rich in sodium nitrate—the production of which Chile holds a world monopoly—copper, gold, silver, and manganese of the metallic minerals and iodine, borates, salt, coal and potash of the nonmetallic minerals. The metallic minerals are associated with igneous and metamorphic rocks while the non-metallic minerals are most abundant in the desert regions to the north and are chiefly confined to recent alluvial deposits. Add to this the fertile soil of the Central Chilean valley, and the vast forests to the southward, and you have a country rich in future possibilities which, with adequate capital and better means of transportation, will contribute very materially to the future welfare of the Western hemisphere. It is no wonder that the Incas sought to extend their empire into this region and the later the Spaniards were most persistent in their attempts to conquer the country.

The Development of the Resources.

A brief discussion of the development of the natural resources of Chile, in so far as they are related in any way with the production of sodium nitrate, will likely be of interest. The metals were the first to be mined; their exploitation having been carried on long before the invasion of the country by Spain. The mining of silver and gold were the first to be developed. Silver mining was at its height during the Seventeenth and Eighteenth centuries, while the height of gold mining continued until the middle of the Nineteenth century. The exploiting of copper began early in the Seventeenth century. In the Eighteenth century, copper mining extended northward into the provinces of Atacama and Aconcagua and at the beginning of the Nineteenth century the industry had grown to such proportions that Chile was the most important copper producing country in the world. By 1853 the output had reached 15,000 tons and by 1876 52,000 tons. This was the high water mark of Chilean copper production. Up to 1882, Chile ranked first among the copper producing nations, being superceeded after that date by the United States. In many cases modern machinery is not used in obtaining the copper from the ores and there is a growing tendency toward production on a large scale rather than by a number of small enterprises.

Large deposits of iron ore exist in various parts of the republic. In many places it is of excellent grade testing sixty to seventy-five per cent pure iron. Lack of coal and transportation facilities have delayed the exploitation of this resource. The most im-

portant development at the present time is being made by the Bethlehem Steel Company, in the province of Coquimbo. Manganese which is so important in the manufacture of high grade steel, is found chiefly in the provinces of Coquimbo and Atacama. The ore occurs in parallel beds, varying in thickness from one to five feet. These are interbedded with chert and limestone. The beds are often continuous for long distances and dip steeply to the east. The ore yields about forty per cent manganese and three per cent iron. In the Coquimbo province, the ore is often associated with volcanic rocks.

The production of coal is not an important industry in Chile. It occurs in many places, but the mining is confined to the provinces of Conception and Valdivia. Coal occurs in the Miocene rocks of the tertiary strata. The seams dip toward the west. Folds are absent, but faults are very common. Usually three seams are found, ranging in thickness from three to six feet. The nature of the seams and their depth below the surface make the mining of this resource very difficult.

In the southern part of the province of Tarapaca are found immense deposits of sodium chloride. These occur near the surface and shafts eighty-three feet deep have failed to reach the underlying rock stratum. The salt found in this region often tests ninety-nine per cent pure.

The Nitrate Industry.

Historical.

Much as the above resources have contributed to the country's commercial importance in the past, the fact remains that without her wonderful deposits of sodium nitrate, Chile would have remained an unimportant and insignificant country of South America. Sodium nitrate has made Chile great and her future prosperity is inseperably associated with that important resource.

The history of the nitrate industry, like that of every other successful enterprise, is extremely interesting. It seems that the value of this mineral as a fertilizer was known to the Inca Indians, but it does not appear that they made much use of it. Tradition says that the Indians of Bolivia came down from the plateaus, for nitrate to use on their crops, and it seems that they devised a way of refining it. Prior to the Nineteenth century, however, the world knew nothing of this valuable mineral. In 1826, a Frenchman named Hector Bacque, established the

first nitrate works on the pampa back of Iquique. He was followed by Smith and Gildermeister, and in 1830 the first important exportation of nitrate began. A part of these deposits belonged to Peru and a part to Bolivia. As the various republics of South America gained their independence from Spain, their territorial limits were somewhat loosely defined. The discovery of these rich deposits to the north of the then limits of Chile offered a splendid pretext for a precipitation of hostilities between Chile, on the one side, and Peru and Bolivia on the other. The outcome of this war, lasting from 1879 to 1883, was very decisive. The rich nitrate fields of Antofagasta were wrested from Bolivia and she was further handicapped by being deprived of an outlet to the sea. Another region equally rich in nitrates was obtained from Peru. This was the province of Tarapaca. The province of Tacna-Arica, to the north, contains but little nitrate. The possession of this region has caused much bitter feeling between Chile and Peru and has threatened to bring on war between these two countries. It seems, however, that this strained relation will shortly yield to amicable settlement. From a small beginning of some 8,000 tons of nitrate, exported in 1830, the business has steadily grown until now nearly three million tons leave Chilean ports every year.

Method of Occurrence.

Much variation occurs in a deposit of sodium nitrate. The layer of rock called, "caliche," from which the nitrate is obtained, may vary in thickness from a few inches to several feet. It may be near the surface of the ground at some places, while at others it occurs fifteen to twenty feet deep; it may contain anywhere from twenty to seventy per cent pure sodium nitrate. The nitrate deposits are found from fifteen to ninety miles inland from the coast and at elevations ranging from three thousand to thirteen thousand feet above sea level. The usual conditions met with in the nitrate fields are somewhat as follows:

1. A layer of loose surface soil, sometimes pebbly, but often fine and scattered by the wind. This material is often feebly cemented together but its removal is never a difficult matter. This is called the "chuca" layer, and varies in thickness all the way from three or four inches to several feet.

2. The "costra" layer. This is composed of pebbles, sand and clay, and is usually two or three felt in thickness. Often the materials composing it are so firmly cemented together as

to form a resistant covering over the underlying nitrate "ore," in which case it is necessary to remove it by blasting.

3. The "caliche" layer. This stratum is richest in nitrates and is used almost entirely for obtaining them. It varies greatly in thickness, and has an average composition as follows: Water, two per cent; nitrate of soda, fifty per cent; common salt, twenty-one per cent; silica, ten per cent. Small percentages of nitrate of potash, sodium sulphate, lime sulphate, lime phosphate and iodate of potash are also found. "Caliche" is usually white or gray in color.

4. The "congelo" layer is composed of sand, pebbles and clay. Uncemented debris containing different salts, chiefly of sodium, magnesium and calcium is also found. All the layers of material in a nitrate deposit contain some sodium nitrate, but usually the percentage in all, except the "caliche" layer, is too low to make their exploitation profitable.

Method of Mining.

A hole about six inches in diameter is made through the "chuca" and "costra" layers and into the "caliche." The lower portion is enlarged considerably by scooping out the "caliche," preparatory to filling it with gunpowder or dynamite. After the charge has been placed in position, and the hole firmly filled with the excavated material, it is fired by a fuse and immediately a large mass of earth is hurled into the air. The large blocks which often result from the blast are broken up by hand labor and the "costra"—a low yielding nitrate layer—is separated from the richer "caliche." The "costra" is left on the field and the "caliche" is loaded into iron carts drawn by mules and taken to the refining plant. The men who drive the carts are paid by the day, the number of trips varying with the distance of the deposite from the refinery. Sometimes narrow gauge railroads are built into the workings and the mule teams are replaced by small trains. The nitrate laborers are mostly Chileans, with a few Peruvians and Bolivians. It has long been the custom for Chile to depend upon her own peasantry for her labor, rather than to import African slaves or Asiatic coolies.

Method of Manufacture.

After the "caliche has reached the refinery, it is coarsely crushed so that the nitrate will dissolve out the more readily and placed in large tanks. These are in sets of three and are made of one-half inch iron plates, strengthened at the sides

by cross bars. Each tank holds about sixty tons of "caliche." To facilitate cleaning, there are at the bottom of each tank two doors that open from the outside. On the inside of these tanks are coils of five-inch pipes which encircle the tanks five times and are placed nine inches from the sides. The tanks are filled with water and "caliche." Through these pipes live steam is passed, raising the mixture to the boiling temperature. This steam was formerly generated as a result of the burning of coal, obtained from England, but within recent years oil obtained from Mexico and California is used for this purpose. Indeed, the business has reached such a magnitude that six hundred thousand tons of oil are used annually for that purpose. After boiling for two or three hours the liquor on the top of the solution is drawn off and fresh "caliche" added. The liquor drawn off is sent to the crystallizing pans and the leaching of the mixture continued, first at the boiling temperature again, and then at lower temperatures. The whole operation takes eighteen to twenty hours per tank.

The crystallizing pans are made of iron plate eighteen by twenty-five feet and two feet nine inches to three feet three inches deep. The crystallization process usually requires five to six days. After the process has gone on sufficiently long, plugs are removed near the bottom of the pans and the mother liquor is drawn off into a lower reservoir. The nitrate when drained is put into cars, sent to the drying floors where it is dried for about five days before being bagged for shipment. The bags weigh about two hundred pounds each. From the mother liquor, which contains only about one-half of one per cent sodium iodate, comes the world's supply of iodine.

Uses and Economic Importance.

The industrial prosperity of the Chilean republic is due, in large measure, to the revenues derived from the nitrate industry. By far the largest part of the nations expenditures are paid from the tax of fifty-six cents, imposed on each one hundred pounds of nitrate exported from the country. About thirty millions of dollars are collected in this way every year. This money is used for public improvements and for paying the salaries of government officials, as well as in various other ways. Since Chile came into possession of these deposits, as a result of the war with Peru, she has collected more than three hundred millions of dollars of revenue.

Much speculation at various times has been current as to the

extent of these deposits and the length of time the working of them will continue profitable. Careful surveys by the Chilean government show that but five thousand eight hundred square kilometers of the known two hundred thousand square kilometers of deposits have been or are being worked. The probable amount of the "ore" is sufficient to last two hundred years even with a considerable increase over the present rate of production.

Much of the nitrate producing regions is still in the hands of the government, which encourages foreign as well as Chilean capital to operate the mines. About one-third of the privately owned deposits are in the hands of the English, about one-third is owned by Chileans, while the Germans control about one-sixth. Very little of the land is operated by United States capital.

There are many uses made of sodium nitrate. The chief ones are, of course, as a fertilizer and in the making of explosives. By far the larger proportion of the output is used for agricultural purposes, but its uses in other ways are of much importance. Some of the more important of its uses other than as a fertilizer are as follows:

1. In the manufacture of iodine. The mother liquor obtained in the preparation of sodium nitrate contains about one-half of one per cent sodium iodate. This is treated with a solution of sodium bisulphite. The iodine separates out in a solid form and is filtered off and further purified by resublimation. By an agreement among the nitrate producers, its production is limited to every sixth year so that the market may not be overstocked.

2. In the making of nitric acid. This acid which has such a great variety of uses in the manufacture of sulphuric acid, in coal tar dyes, in making explosives and as a re-agent is made by using the sodium nitrate obtained from the "caliche" of Chile. The operation consists of bringing sodium nitrate into contact with sulphuric acid.

3. In making sulphuric acid, which has such a great variety of uses.

4. In making sodium nitrite. This is made by heating sodium nitrate with lead. The product is extracted with water and the solution is allowed to crystallize when anhydrous sodium nitrite is formed. This is used in making coal-tar dyes and as a chemical reagent. The production of this compound amounts to about $600,000 annually.

5. In making potassium nitrate. The "caliche" contains anywhere from a trace to seventeen per cent potassium nitrate. The average is two to three per cent. The du Pont Nitrate Company began the production of potass um nitrate from the "caliche" as a byproduct in the manufacture of sodium nitrate in 1914, and now has a production of one thousand two hundred tons of potash annually. The future possibilities of "caliche" as a source of potash are very encouraging.

Thus we see that a region formerly considered barren and a waste country, has been made to yield abundantly of the things that supply many vital human needs and thus contribute very materially to the happiness and well being of mankind.

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PRODUCTION OF CLAY IN 1922.

The output of clay mined and sold as clay in the United States in 1922 amounted to 2,647,700 short tons, valued at $8,330,514, or $3.15 per ton, according to the Department of the Interior, as determined by figures compiled by the Geological Survey. These figures show an increase of fifty-two per cent in quantity and thirty-eight per cent in value as compared with those for 1921. The figures represent only clay sold as clay by the original producers, they do not include the much greater quantity by clay that was burned into clay products by the producers themselves.

The output of kaolin, the clay that is used in making high grade pottery and porcelain as well as paper and other products, amounted to 275,675 tons, valued at $2,346,095, an increase of sixty-nine per cent and forty-nine per cent, respectively, as compared with 1921. The clay of largest production and value is fire clay. The sales of fire clay in 1922 amounted to 1,679,220 tons, valued at $4,633,486, an increase of forty and thirty per cent, respectively, as compared with 1921. The output of every kind of clay as classified by the Geological Survey in its statistical report increased in quantity and value in 1922 as compared with 1921 except slip clay which decreased slightly in quantity, and stoneware clay, which decreased in value.

The imports and exports of clay also increased in 1922 as compared with 1921. The total imports of clay were 350,570 tons, valued at $3,321,875, an increase of sixty-eight per cent in quantity and value. The imports of kaolin, the chief clay imported, amounted to 310,136 tons, an increase of ninety per cent as compared with 1921.—[*U. S. Geol. Survey.*

THE TEACHING OF HYGIENE AND SANITATION.

By Elliott R. Downing,
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(Continued from October)

It is more difficult to influence the general housing situation, the carelessness of the mothers before and after the birth of the child, and the general unsanitary condition of the homes. This is being attempted, however, by several methods; namely, by co-operation with the visiting nurse, by the use of charts at Parent-Teachers' meetings, and by surveys of housing conditions.

When the teacher, in the course of her survey of health habits among the children, discovers a home where instruction is evidently needed, she reports to the visiting nurse. In some cities there is such a nurse directly connected with the school; in other cities the visiting nurse is maintained by the charitable organizations. She visits the home and undertakes to give the needed help. In some of the small cities, the situation is being met by the Parent-Teachers' Association through whose co-operation needy parents are visited by a tactful, friendly visitor—a mother willing to devote some time to establishing friendly relations with such a family and to teaching the mother how to run her household.

In some schools, such information as has been given in the tables above is put on charts by the children, or, if the children are too young for this, the high school pupils are interested in the project. Then, on various occasions during the year when the parents are to be at the school building, the charts are hung in the rooms and hallways where they may be seen. Each chart is in the special care of two or three children whose business it is to get the parents to look at their chart while they explain it. If the school has a large foreign clientele, the charts are in the care of children who can translate the contents to the visiting parents of their own nationality. This method of teaching health by charts applies not only to the topic immediately under discussion but to all of the health activities in the school which demand the co-operation of the parents. There is a series of such health charts prepared by the Committee on Health Problems of the National Council of Education. The catalogue of these charts may be obtained from Dr. Thomas D. Wood, 525 West 130th Street, New York (25c).

Some wide-awake teachers are trying to arouse their pupils to the social problems involved in community health by having

the children study the housing conditions in the community. A map is made of a congested area, showing each residence. From the health department there is obtained information in regard to the location of all cases of serious communicable diseases. This information is put upon the map. A dot of a given color is used to show the location of each case of disease: red dots, perhaps, for dysentery; blue dots for pneumonia, etc. A good residence section is mapped in a similar way. It is quite possible thus to show in a very graphic way how the congestion affects the number of cases of disease, and that certain buildings are constantly harboring dangerous diseases.

In some cities the school children are personally making surveys of the unsanitary districts in order to see how unsanitary they are and to get acquainted with children to whom they can carry pleasure in the way of toys, needed clothing, and a sense of real friendship. Teachers are making use of the Boy Scout organization for this sort of work, and the results are sometimes startling and pleasant.

A Boy Scout troup connected with one of the churches in a rather elegant residence district of Chicago undertook to make a survey of conditions in a block "back of the Yards." They decided, after a cursory examination of the area, that it would be impossible to deal with the entire block and that they would pick out, therefore, the worst ramshackle building and concentrate their efforts on it. They succeeded in establishing friendly relations with a number of boys living in this particular building; they found that some of them were Boy Scouts and they invited them to a meeting of their troop and were in turn invited to a meeting of the troop in the congested area. Finally it occurred to the boys to prepare a report on the conditions found in this particular building and submit it to the owner. It was an audacious undertaking, but youth is always audacious. Now, it happened that the owner of this dilapidated, unsanitary structure was an elder in their own church. Undaunted, however, the committee waited upon him and presented their report in no uncertain language. Needless to say, it was an embarrassing conference for at least one person present. The owner professed, however, that he never had seen this property which he had purchased through a real estate agent. Fortunately, this particular story turned out well. When the owner actually found out the existing conditions, he tore the old building down and replaced it by a very decent apartment house.

It is evident from the tabulation of the causes of death of the children of school age that we need to concentrate attention on accidents, which are the chief single cause of death in this period; on diseases that may be known as the impure air diseases, influenza, diphtheria, pneumonia, and tuberculosis; and on certain other contagious diseases.

Accidents, it will be noted, are also a cause of major importance in the pre-school years. The following analyzes the situation somewhat better:

Cause of Death	No. of deaths 5-14 years	No. of deaths under 5 yrs.
Automobile accidents	2091	608
Drowning	1435	952
Burns, other than conflagration	1032	2913
Falls	475	620
Street cars	192	136

The five causes given account for 5225 out of a total of 7873 deaths by accidents between the ages of 5 and 14, inclusive, and of 5229 out of 7956 under 5 years. They are, by all means, the most important causes of accidental death. While there are many other causes, no single one makes a large item.

The schools are beginning to realize that here is a matter in which education can help reduce the mortality. It is worth while getting in mind the enormous death toll in this country from accidents. In the city of Chicago forty deaths occur weekly from accidents. Annually, in the country at large, we kill about 30,000 persons in industrial accidents and more or less seriously wound ten times as many. The United States was in the World War for nineteen months, during which time fewer than 300,000 soldiers were wounded. More than ten times that number of persons were accidentally wounded in this country during the same period. About 77,000 American men were lost during the war by wounds, disease, and accidents. During the same time we lost, in round numbers, 126,000 men, women, and children from accidents in this country.

Just to have such facts spread from the school to the community is to make all realize something of the enormity of the annual toll in deaths and in those crippled from accidents.

The schools are doing much more than this, however. They are taking active part in an endeavor to reduce the number of accidents. A survey is frequently made, using the data that can be obtained from the city statistician. This results in the drawing of a map of the city upon which there is shown by a dot the location of each death due to accident. This reveals at once

the dangerous crossings and the industrial plants where accidents constantly recur.

Some schools are using the older pupils to serve as police assistants at the street crossing near the school, and to supervise the playgrounds. The children are being given instruction in many cities on how to cross a street. Such instruction is not merely verbal; the teacher actually takes the pupils out to a near-by busy thoroughfare, divides them into small groups and has them cross the street, a group at a time, under her supervision. In this way, they learn to look up and down the street for coming vehicles, to judge when the street is sufficiently clear to make passing safe, and to avoid running unnecessary risks.

As a result of instruction of this sort, the number of deaths in St. Louis due to accidents was reduced from 510, in 1917, to 417, in 1918, and 320 in 1919. In June 1921, the city schools of Chicago put on an intensive campaign of instruction in regard to prevention of accidents. During July and August, while the number of deaths from accidents increased in general by five percent over the preceding year, the deaths of children of school age decreased by five percent. The statistics are still meager, for even in communities where instruction in the public schools is being given, in regard to accidents, accurate data are difficult to obtain.

In some cities, the street railway company has put at the disposal of schools during the less busy hours streetcars manned with motormen and conductors. These cars are run on switches or little-used lines near the school buildings and the teachers take their pupils out and teach them how to properly get on and off a streetcar.

In a number of schools, instruction is being given in First Aid. One of the most effective means of accomplishing this is to have some local Boy Scout troop give a demonstration of First Aid Work in the several rooms of the school building. Then the teacher may drill the pupils themselves in the work the scouts have demonstrated. Very commonly. however, the Scouts are quite willing to drill a squad of the pupils in each room until that squad is sufficiently proficient to pass the instruction on to the other pupils. In this way, the pupils not only have received instruction as to what should be done to resuscitate the person who has been drowned or who has been severely shocked by an electric current, and how to treat a case of severe burn, etc., but they have also been put through the motions a sufficient number of times to insure prompt and intelligent action in case

of emergency. There are moving picture reels now available on First Aid topics, and those schools provided with a projection outfit can receive the preliminary instruction from the screen. It is important to recognize, however, that such instruction is relatively useless unless followed by repeated drilling of the pupils in the processes they have seen pictured.

It is hardly necessary to more than mention the fire drill as a means of accident prevention. In practically all good schools this is now a part of the regular program. The aim of the drill is to habituate the pupils to an orderly and rapid exit from the building under the leadership of the teacher so that, on occasion of necessity, they will accomplish this, even in the confusion of an actual fire. The drill, therefore, needs to be given frequently enough to lead to the formation of a habit.

Next to accidents in importance as a cause of death among children of elementary school age comes a group of diseases that may be justly designated the impure air diseases, including influenza, diphtheria, pneumonia, and tuberculosis. In the attack on this group of diseases, it is important to put certain facts before the pupils and, through them, before their parents. In the first place, these diseases are winter diseases. This apparently means that when we are likely to keep indoors, sleep with windows closed, live in poorly ventilated rooms, and ride in closed and crowded street cars, we are most susceptible to such contagion. The evident remedy for such a situation is to avoid as far as possible such conditions, and schools the country over are doing many things to avert them.

Of course the school room itself should be well ventilated. No device for ventilation has yet been found as efficient as the open window and none is so cheap. The open air school is looked upon as a very desirable remedial agent for the cure of anemic and debilitated children. Why we should insist that a child be actually ill before he may have the advantage of such a simple sanitary measure is rather incomprehensible. The essentials of the open air school are abundant fresh air, a supply of warm wraps for the children, a sunny exposure, frequent rests on couches, between-meal lunches, and a careful supervision of all the out of school habits of eating, sleeping, play, etc., that affect the health. See U. S. Bureau of Education, Bulletin 23, for 1916.

One of the items to be included in the survey of the sanitary conditions that prevail among the school children is the ventila-

tion of their sleeping rooms. Let the teacher find out under what conditions the children actually sleep, whether the room is well ventilated by a wide-open window, how many occupy the same room, how many occupy the same bed, and whether or not the day clothing is removed and a night robe provided. Such inquiries, together with a clear statement on the part of the teacher of the ideally hygienic conditions of sleeping, cause many children to insist on something like well ventilated and sanitary sleeping quarters, especially if the teacher is persistent in her inquiries and her appeals. In the badly congested residence sections of the city and even in the country where the terror of the evil influence of the night air still dominates ignorant parents, it is difficult to establish anything like sanitary sleeping conditions, yet persistence accomplishes reform. The teacher will find it necessary to labor with the parents in this as in other matters for the achievement of hygienic ideals.

In dealing with this group of impure air diseases, it is well for the teacher to know the sources from which she can get good material for the reading table. A great many states publish pamphlets on these diseases and their prevention. Such pamphlets can be obtained from the state department of health, addressed at the capital of the state. The State Charities Aid Association of New York, 5th Avenue and 22nd Street, puts out a number of pamphlets on tuberculosis, its prevention, and the care of the tubercular patient.

Aside from the fact that simple and nutritious foods, plenty of good air, exercise in the open, adequate sleep, and general good habits, are effective preventatives, the facts which need to be in the pupil's mind as a result of reading on these impure air diseases are somewhat as follows:

Tuberculosis is a communicable disease. The germs of the disease are found in the mucous raised by the patient. The patient should, therefore, receive this mucous on pieces of paper or old cloth which are promptly burned or thoroughly sterilized. When this is not the case and the mucous is left to dry on the floors, clothing, or hands, the germs are likely to get onto the food of other members of the family or to be taken in by persons living in the same house or using the same conveyances. The age at which tuberculosis is most commonly contracted is early childhood, when the youngster creeps continually and instinctively puts all objects in its mouth. As a rule, the tubercle bacilli in the organs in a healthy individual are surrounded by a wall of connective tissue. They are thus imprisoned and unable to work injury. In such a condition, however, they are extremely long-

lived; and, if in later life the individual is weakened seriously by a severe attack of disease so that the body draws on its reserve material, the prison walls may be resorbed and the tubercle bacilli set free to begin rapid multiplication when the individual is more or less at their mercy. It is evident that the tubercular patient should be extremely careful to sterilize the hands before preparing food for other members of the family and not to perform such duties at all if it is possible to avoid them. In fact, it is well for the patient to be kept away from other people.

The cure of the disease is accomplished by rest, preferably in bed, living day and night in the open air and sunshine, and feeding frequently and abundantly on the highly nutritious and easily digestible foods. These will be prescribed by a physician. Under such conditions, the white corpuscles of the blood have a chance to multiply rapidly and eat up the tubercle bacilli.

Diphtheria (membranous croup is diphtheria) is caused by a germ that locates in the nose and throat. It gives rise to a poison, or toxin, which causes death by stopping the respiration and the heart-beat. This poison is counteracted now by the injection into the patient of an antidote known as antitoxin, a treatment which is entirely safe in the hands of a reputable physician. The earlier this treatment can be given in the course of the disease, the less likely the patient is to die. Since antitoxin was first applied to the cure of diphtheria in the year 1894, the number of deaths from diphtheria has steadily decreased.

While only two of the contagious diseases of childhood occur among the ten most important causes of death in children of school age, there is an enormous amount of unnecessary sickness from such diseases, even if they do not result in a very great mortality. Thus, in the year 1921, while there were only 120 deaths from measles and 180 from scarlet fever in Chicago, the number of cases of measles was 8731, of scarlet fever, 5459. The total deaths from the six most important diseases of this kind were 1,140, but there were 38,080 cases. It is very evident, therefore, that the mortality rate gives little indication of the loss both in vitality of children and in the cost of such illness.

The average parent still looks upon these diseases as necessary evils. It is commonly thought that the sooner the child catches them and gets through with them, the better off he is. It is this attitude of complacent indifference that needs to be altered by our school instruction, for these contagious diseases of childhood are not necessary; they are merely evidence of our stupidity

and unsanitary habits. Every attack of such disease reduces the vitality and resistance of the child, besides incurring needless expense. The death rate from these diseases has been constantly declining as we have learned to isolate the sick, to sterilize the discharges from patients, and in general to maintain better sanitary conditions. We know enough now to banish these unnecessary diseases if we could get the co-operation of all people in the community.

One of the most potent factors in the spread of the communicable diseases of childhood is the school itself. We confess this repeatedly when we close the school as one of the first essential measures of the control of an epidemic. With adequate medical inspection of school children in order to detect and exclude incipient cases of disease, with proper sanitation of the school room, including such simple things as the daily sterilization of children's desks, of floors, and common utensils, and with proper ventilation and an adequate exposure to sunlight, the school room can be made a perfectly safe place for the children present.

A few years ago, Professor C. F. Hodge, then at Worcester, Massachusetts, persuaded the principal of one school building to organize in each room a sanitary corps. Two or three of the children provided with simple costumes as insignia of their office, came to school early and wiped off desks and the commonly used apparatus such as erasers, globes, etc., with cloths kept wet in an antiseptic solution. The teacher of each room sprinkled the floor with sawdust saturated with the same solution so that the janitor more or less thoroughly sterilized the floor while sweeping. These simple expedients were sufficient to reduce the absences nearly to the vanishing point for the year.

One of the complaints that makes no showing upon the mortality statistics is the common cold, and yet it paves the way for diphtheria, influenza, bronchitis, pneumonia, and other serious diseases. Probably there is no single complaint that detracts as much from general efficiency as does this usually ignored disease. Children and parents need to realize that colds are contagious, like measles or scarlet fever, and that a cold is caught by contact with someone who has a cold. It should be recognized also that the term "cold" covers a variety of diseased conditions.

A second mass of data is being accumulated from the physical examination of pupils showing the defects of school children. These may be briefly cited. In a tabulation of the results of the examination of more than a million school children in twenty-five cities, dental defects were found in 16.4%; skin diseases like

impetigo and eczema in 9.1%; diseased tonsils in 8.8%; adenoids and nasal obstructions in 8.5%; wounds, sores, and sprains in 7.6%; vision defects in 5.1%; aenemia and malnutrition in 2.8%; enlarged glands in 2.7%; deafness in 1%; heart defects in .3%. The first five of these total 50.4% of the total defects found, and all the ten, 62.3%.

It is impossible to get unanimity of opinion on the percentage of such defects for we have as yet no standards on which to base judgment. Thus, in some reports, "dental defects" means any departure from a normal set of teeth, while in others only sufficiently serious decay, or irregularities sufficient to interfere with school work are included. Out of a total enrollment of 76,149 pupils in Newark, N. J., in 1920, 25,035 were defective, and of these, 50.23% had defective teeth, 11.65% enlarged tonsils, 9.96% defective vision, 5.84% deformed palates, 5.32% were under-nourished, 5.1% had enlarged glands, 3.34% nasal obstructions, .83% speech defects, .79% skin diseases, and .76% defective hearing.

Denver, a typical western city, reports in 1917-18 a total enrollment above second grade of 25,450 of whom 20,453 were examined and 16,877 were found defective. The principal defects are as follows: defective teeth, 2746; defective vision, 2576; diseased tonsils, 2378; defective speech, 638; adnoids 505; defective hearing, 251.

Such reports might be indefinitely multiplied, but these are sufficient to indicate that we lack standards for the determination of the defects of children, and they also show that there are some ten defects that include the great majority of those affecting school children.

It is interesting to compare these data regarding school children with a third mass of facts—those data discovered by the examining boards when they inspected drafted men. The ten most important causes of rejection of men were: heart defects, defects of bones and joints, eye defects, developmental defects, hernia, teeth defects, mental defects, nervous defects, ear defects, and flat foot. It is to be noted that a number of these defects are identical with those found in school children. It is therefore evident that these defects disclosed by the examination of school children are not such as disappear at maturity but that they carry over into adult life. It is furthermore evident that there is still an opportunity for instruction in physiology and hygiene to so establish habits of healthful living as to reduce

very materially the defects of adults and to produce a sturdier and fitter type of American.

It will be unnecessary to take up in detail a discussion of what American schools are doing to remedy the situation disclosed by such typical cross-sections of our population as we have in this data compiled from the examination of large numbers of school children and drafted men. We may mention one or two items as typical of the attention which is now being given in school to these matters. It is found that malnutrition, defective teeth, defective hearing and similar defects are conspicuous causes of retardation. It has been estimated, for instance, that one seriously decayed tooth means three months retardation. It is, therefore, wise public economy on the part of school authorities to spend money in the detection and rectification of decayed teeth, since such attention is less expensive than to give the child the additional three months instruction for every decayed tooth.

It is only recently that we have become aware of the prevalence of malnutrition in the schools. As a result of the measuring and weighing of many thousands of children throughout the country we have accurate notions of the average weight and height for any given age and this may be taken as a standard, making due allowances for the average deviation, and also taking into consideration racial and family standards. In a great many American schools it is now a part of the regular routine to measure and weigh all children once a year and to weigh and measure retarded children more frequently.

It is quite impossible in the space of one article to cite in particular all of the causes of mortality, morbidity, and defects among children and to indicate what the schools are doing in an endeavor to establish preventative health habits and to disseminate in the community the mass of information that is needed to successfully cope with the problem. Sufficient data have been given above to make it apparent that *we can find an adequate basis from which to determine the types of topics that should be considered in a course in physiology and hygiene and to show how, on the basis of such facts, the curriculum and methods of instruction are being rapidly modified.*

LABORATORY VERSUS RECITATION.

By E. M. Jones,

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This article has no promise of making a settlement of all the difficult questions involved in discussing the old educational question of the relative values of our modern laboratory courses, as compared with the strictly lecture or recitation courses. The laboratory in which the writer labors has not solved the eternal question, neither does it soon expect to do so. This article is to voice some reflections that have arisen in his own mind and by the same token have doubtless arisen in the minds of his fellow teachers.

Our courses in science since the régime of the four-hour course, have been arranged with two hours of recitation or lecture work and four hours of work in the laboratory for the usual four hour credit. We have had a faint suspicion at times that the educational value of the four hours spent twice a week in the laboratory was not educationally equivalent to the two hours of strict recitation required in the same course and have felt that students regard the laboratory days as off days and no preparation is made for them. Social events are quietly slipped into the evening before the laboratory days and various other signs are in evidence that the cultural grind of the course is quite largely confined to the two days of strict recitation, where the preparation of lessons is rigorously required. The writer has also a faint suspicion that the modern college or high school laboratory is one of the least efficient of workshops. A workshop maintained by *outside capital invested* and not by the value of the product produced. We have felt that frequently the question at issue in the average laboratory is not the value of the product or the perfecting of the machine producing it but that it is a sort of busy work arrangement, whereby at certain stated periods a class may repair for its regular twice a week vacation and current events discussions.

The reader will here note that the writer is talking about his own laboratory and not that of his neighbor so, at the outset, he wishes to establish a perfect alibi for any fault-finding or other educational muckraking. At the present moment, it is a serious question whether or not the average student is by temperament or training fitted to profit materially in the average laboratory course. The question is not the value of the laboratory method

for that, in our opinion, is not open to question. The question to state it clearly is: DOES THE AVERAGE STUDENT GAIN A PROPER EDUCATIONAL VALUE FROM THE LABORATORY COURSES WHICH HE PURSUES?

In looking over the various laboratory helps published, we can not but be struck by the lack of originality displayed in the methods of verifying the old and fundamental laws of the sciences. This we believe is less true in the natural sciences than in the physical sciences. We very much fear that we as authors have become mere copyists and as teachers we rather resent any suggestions as to new ways of obtaining old results and of accomplishing well defined proofs of fundamental laws. At times we have a feeling that teachers, as a class, fall easily into ruts from which they are rescued with difficulty. The author of this paper begs to plead guilty at this point to this fault and all this in spite of his efforts to avoid the same. After spending twenty years in the work one grows garrulous and reminiscent and at times thoughtful—we trust at this particular time we are in the thoughtful period and while in this state of mind we wish to discuss some steps we have taken to make our laboratory work here more efficient and avoid the suspicion of busy work laboratory methods.

It is our belief that fewer students really profit by laboratory methods than is generally supposed. We frequently, after a few weeks observation of the student, advise him to choose a course where strict recitation and class preparation is called for and to drop the course where about half the time is devoted to laboratory work true or so-called.

Frankly, we have much difficulty in preserving a spirit of inquiry in our laboratory. The queries are more frequently directed to one's neighbor than to nature. If a student or teacher has not the spirit of true research, there is little to be gained from hours spent in rough approximations of laws and properties of matter. It has been the writer's observation that very few students have an adequate conception of why they are asked to do this, that or the other thing in their laboratory directions. Diligent questioning of the student in his inspections of the laboratory during the progress of the experimenting has yielded him a dearth of real constructive ideas. He has often suggested to the student palpably wrong methods and later returned to find them being implicitly carried out without thought of the possible reasons for the directions or the palpably

wrong methods of obtaining any desired end. The writer is of the opinion that some time in our future educational journeyings we will restrict the use of laboratories to those students who have advanced rather far toward their degrees in college, or other school of like rank, and have showed a distinct ability to really profit by laboratory manipulations. The regular "Visiting hours" in our own laboratory are on Tuesday and on Thursday, and the writer was a little upset recently by having a student remark to him on Wednesday that he was going to attend a party that evening as he had nothing to do on the morrow. The same student the next day spent the day in the laboratory discussing doubtlessly clandestinely, the previous evening's party, the coming party and the results of the basketball games in all known leagues. All those who have had similar experiences raise your hands. The ayes have it.

The writer once tried an educational experiment a la Louis Agassiz. The reader will recall the story of the great Agassiz, who set a fish before the student with the request that he look at it and upon his return some time later found the inspection completed and the student expressing desire to be told what to do next. The answer was to "Look at it." This method continued for several weeks until the student finally tumbled to the idea, and lived happily ever afterward. Our attempt of the same nature was made upon a promising subject, a bright young man of more than average ability who was, at the time, studying qualitative analysis, and had come to the use of the spectroscope in detecting metals. We set out a complete spectroscope, with all necessary appurtenances, and instructed him to find the spectroscopic lines and investigate an unknown liquid then in his hands. We came back at the end of two hours and he was still searching industriously for the lines. We left him with the injunction that they must be in there because a man named Fraunhofer had once found something to this effect in an instrument of this nature and had recorded his foolish observations for the ubiquitous students who should follow him. We came back at the end of the week and the lines had not been found. We gritted our teeth and waited a month while the enthusiasm of the student had visibly dwindled and his desire to find the lines in a spectroscope had undergone a distinct relapse. We waited two months and no lines in the spectroscope. We were adamant and told him they were in there some place and it was up to him to find them. This was some fifteen years ago and so far as the writer knows this young man has not dis-

covered those lines. We will never repeat this experiment, it was too painful. The young man was graduated from our laboratory and advised to take something more tangible than chemistry. Something he could see without glasses and find without a telescope. All this experiment to try out some one's theory that the student should be made to discover for himself the facts of nature. Some students never will, and they are good students, too. They simply are not adapted to the laboratory method.

We have hit upon the plan here of gently but firmly changing a student's course for him when he doesn't fit into the laboratory method, for at the present time a science taught in any but the laboratory way is held null and void and of no worthy repute. We are not in accord with this view but can not of course materially alter it hence must follow it. There is however no well defined objection to weeding out students which the method does not fit and whose education is little benefitted by the regulation stay in the average laboratory.

Some of the methods we have adopted to secure efficient use of time in our laboratory may be of interest to others who are not entirely satisfied with the results they are getting in their courses, and to those who are not yet convinced that the intensely practical should monopolize all our educational field. Sounds more like the department of Greek talking than the department of Physics and Chemistry in a college, doesn't it?

One of the first things that a student hears when he enters our laboratory, is that he needs a working acquaintance with Greek, a thorough knowledge of Latin, and all the English, French and, yes, German, that the law allows and his ability permits.

We trust in this way to bridge the great gap between the old Arts course and the modern course, which really means a four year sojourn in some place where learning of one kind or another is dispensed.

Upon entering our laboratory, the student usually demurs about the Latin, becomes obstinate about the Greek, and becomes vicious at the mention of German. French is a lesser evil and can be studied the night before the laboratory day in Physics, Chemistry or what not. We have had a fearful time, all in all; we have had little support from the colleges and universities where anything from the Spencerian system of writing to Antigone and mental arithmetic, serves as one of the cogs to grind out a degree of the Bachelor variety—Bachelor of what, is wisely left to the reader's imagination—very wisely, we be-

lieve. One of our great universities requires for its Bachelor's degree, the study of rhetoric. After diligent search, we fail to find any other definite requirement. There are a certain number of hours, to be sure, but they are easily gained by shopwork, music, electrical measurements, cooking, sewing, editing the college paper, bucking the line on the football squad, and studying the birds in little strolls along lover's lane in the cool of the morning, when all the world needs to get out for a little air, anyway, and if credit can be obtained well and good.

Suppose as a matter of illustration, one of our young army recruits should enter the army school of instruction and decide he wanted to polish the cannon for his credit and when he finished that he would take a course in flipping pancakes for the soldiers' mess. Suppose now, the elective system should so prevail that he could gain his knowledge of war in this way, because these subjects interested him and he was entertained thereby. We must, of course, take only such subjects as are intensely interesting to us, so that our attention may the more easily be riveted upon the matter at hand. Few soldiers would choose the course where they rose early in the dewy morning with the bugle call all out for the morning hike of say seven or ten miles. A hike of this nature is not interesting and so the poor soldier elects the wrestling with greasy skillets. War breaks out, the soldier is sent to duty with his diploma fresh with the ink of official recognition. Poor soldier. Poor student that enters into the active field of life with a hodgepodge education of no related values and expects to be received as a cultured, educated unit. Brethren, it can not so be.

Let us gird up our loins, we teachers, first polishing the dust off of our own mental machinery and then wisely assist the student to steer his course through the rough breakers of a real education and not through one of the wishy-washy varieties, all too common in all institutions of learning of the present day. Glance at our text books on Physics. Pictures of aeroplanes. Wireless sets. Monster steam engines. Air machines and all the latest devices to catch the jaded attention of the pleasure-surfeited youth who are sent to us daily for the polishing and sharpening of the machinery for the fray of life.

First steps in the making of laboratory courses equal to the old Arts courses in mental training, is for the teachers of such courses to really waken up to the fact that their course is not NOW the equivalent in mental training, culture, or character

building of the arts' course of a generation ago. As a scientist this admission is a plain duty. For the first rule of a scientist is to receive and accept truth, no matter how unwelcome the truth or how disagreeable the source. (a) The teacher is not NOW giving sufficient thought to his laboratory courses. He depends to too great an extent upon some manual or manuals that may serve as a busy work series. (b) The teacher is not sufficiently thorough in his revision of laboratory notes and reports. Grading by the pound or the number of pages is all too common. (c) Reports of students are not carefully supervised as to content or arrangement. (d) The kernel of the matter is not sifted out and brought into prominence. (e) Neatness and grammatical arrangement are not sufficiently insisted upon. (f) Laboratory demeanor and attitude is not sufficiently supervised. (g) The average laboratory work done in high school and college could be as well performed by a man, chosen at random from any good shop or factory, whose school training was sufficient to enable him to read the directions and follow them as is usually done by the student taking that course. The correlation between the class and the laboratory is so loosely kept that a question occurring in the class discussion the following day may recall to the student no personal experience with the matter under discussion. This is not a theoretical or hypothetical condition. It is an actual one in any laboratory and the honest teacher will be the first to admit the same. There are varying degrees of the malady as is to be expected and there are efficient laboratories. These latter should not be confused with the kind that are exceedingly difficult to go through with passing marks. In fact, the difficulty of obtaining a credit in a laboratory is, in the writer's opinion, very little related to the actual educational value derived from work there.

A well equipped laboratory is not necessarily the best laboratory, although other things being equal, it is possible to do more work in less time there than in a poorly equipped laboratory. There are some advantages even in a poorly equipped laboratory, for the discoveries in any laboratory actually made by undergraduate students are negligible and will be so for some time to come. The function of the laboratory, it would seem, is to teach the accompanying manipulation of a mechanical nature along with the mental manipulation necessary to solve the problem at hand. And there must always be a problem at hand. Laboratory work without a definite problem of a well defined

nature before one, is time wasted. Educationally, it may be time well spent as an apprentice in some mechanical line, but it is nothing more than this, and should be so recognized. In our own laboratory, we insist upon the student being able to formulate clearly and definitely the problem upon which he is working. We attempt to explain to him that the difference between himself and any other worker in a factory is that he is paying for the privilege, and the other worker is getting paid for his work and unless the mental training is being carefully obtained, he is a very foolish individual. Sometimes, we succeed in bringing home this difference and sometimes not. It is sometimes instructive to bring into your laboratory a factory worker of no knowledge whatever of the subject at hand, place before him the directions the student is using and watch him perform, in a mechanical way, the very operations your student is performing. An object lesson of this kind is needed very often to first awaken the student, and perhaps the teacher, to the fact that they are sick with an educational disease which has its origin in the propaganda of the trade schools of money for your work. Everything practical, everything that one can use in later life. Little mathematical and little theoretical training.

How many really scientific magazines do you have in your school library? Please do not mistake the question. We do not mean those with flaming cover designs, depicting all sorts of impossible and improbable stunts of a bizarre and curious nature which are cooked up for the highly-whetted appetite of the young American boy, who when he has read these highly colored and imaginative sheets vill hardly find time and opportunity to sit down and thresh out an abstruse mathematical demonstration of a real scientific problem, as is contained for instance in any of the British scientific reviews and in our own little known really scientific journals.[1] Feeding our young upon these highly colored articles introduces a real problem for our prosaic professors, who can not compete with them in imagination and, oftentimes, in sheer nonsense. Who wants to read the philosophical magazine, or the astrophysical journal? Our English cousins want to read them and do. So, also, do the German youth. They take real pleasure in digging down below the superficial surface of things and getting to the real heart

[1] A little known law, Fechner's, might well be quoted at this point, the Psycho-Physical law, "The increase of stimulus necessary to produce the smallest perceptible change in a sensation is proportional to the strength of the stimulus already present." Weber or Fechner's Law.

of the question; to experience the thrill that any lover of real problems experiences upon the solution of an especially difficult and refractory one.

The writer believes that the colleges and schools are being led by our students rather than they themselves mapping out the courses. One real thinker in America always has been able to, and is doubtless now able to guide the destinies of the nation, wherever he desires. This is, doubtless, as it should be, but we can not avoid the suspicion that if the schools were giving a real education to our youth it might be a trifle more difficult to lead without a firmer foundation of fact than many of our modern movements show.

Upon every sheet of paper used in our laboratory appears these words: DO YOUR OWN THINKING. Rather a big task to put up to a student when even the teachers and instructors really do very little of their own. A special blank is given each student when entering the laboratory. Upon this blank appears a space for the formulation of the problem at hand, another line gives place for references, another line gives place for the data that may be useful for determining the answer to the problem. This data, unless othwerise provided for, and by permission, is to be extracted from nature by way of the laboratory methods given for guidance. The directions of the manual are seldom followed literally. Individual help from instructors in the ways and means for accomplishing a definite end is given. When the experiment is completed it is handed in and carefully examined as to statement of problem. There also occurs a statement of the problem by authority as a comparison and a reference as to where the statement may be found—a carefully prepared list follows of data and incidental facts noted during progress of the building of a truth from the raw materials of the laboratory.

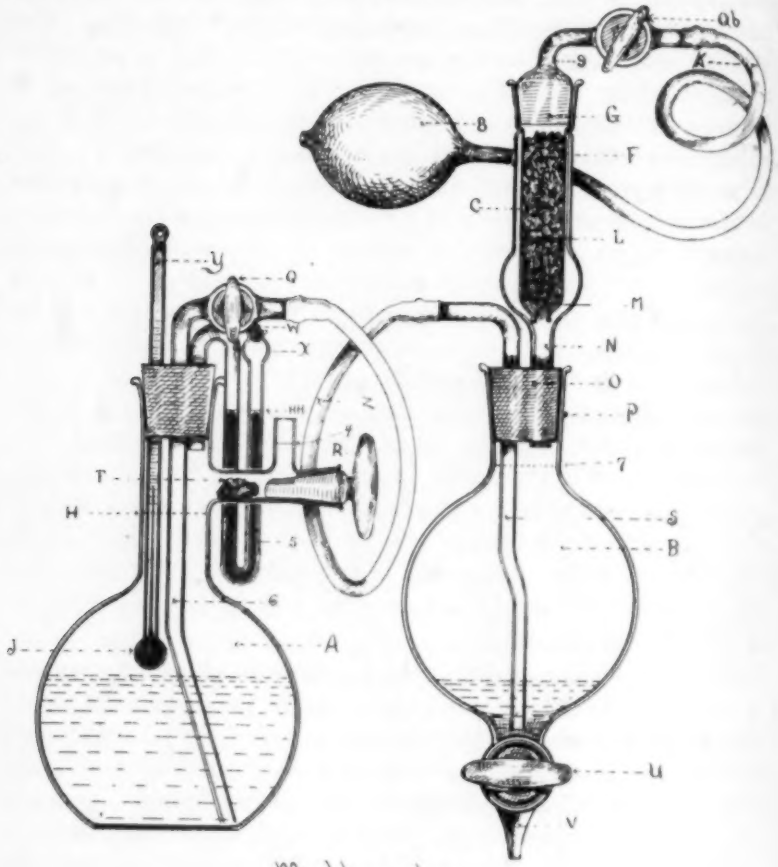
A large number of experiments is not insisted upon. Fundamental experiments are chosen. Highly colored sensational or pyrotechnic experiments are taboo. The class interest is not stimulated by unusual or modern applications to commerce of the law in question. Unless the student can rivet his attention upon the subject at hand without aid of this nature, he is relegated to some other course where this is possible, usually to a course where the four recitations are rigorously required.

We will illustrate the idea by a very uninteresting application of chemical laws, namely, the finding of the hydrogen equivalent

of a metal, say zinc. We have had students spend something like three weeks of laboratory time upon this one experiment alone, before producing results that the instructor deemed worthy to appear in his record. The writer felt sure something was wrong, as there seemed no good reason for the failure to accomplish good results in much shorter time than this. The student was advised to discontinue his efforts and to set up an apparatus later of a different type. The class, as a whole, upon being questioned, had had more or less difficulty in obtaining results with this experiment, so it was planned that the next laboratory period of two hours should be devoted to the problem of the hydrogen equivalent of a metal. The class met and looked forward to an uninteresting session to discuss a disagreeable subject that had no earthly relationship to what they were at the time doing or ever expected to do. The discussion was informal, and the first few minutes were spent in formulating a definite problem and this definite problem was stated by a number of different students in various ways until it was finally simmered down to a method of statement which seemed clear to all members of the class. Interest began to revive in the discussion, as soon as it was clearly shown there was a real problem and the fighting instinct of the students aroused. They began to stifle the early yawns and began to inquire why this, that or the other way could not be used rather than the way the instructor had suggested.

Most of these suggestions had some impracticable part and were gently, but firmly, discarded. One of the first things taught the laboratory class is that in science there are no arguments. Things are or are not true. As soon as a formidable difficulty was encountered, the suggestion was dropped and a new one tried. After simmering the various suggestions down, two or three stood out in sufficiently bold relief to warrant trial. By this time every member of the class was alert and ready either to be creative or destructive. If the pet theory of one had been demolished by the cold, calm logic of another, that individual became a severe critic of all others. and thus the two hours passed and all were surprised when the bell rang and perhaps a trifle impatient at the interruption. We had no results of a tangible nature to show for the two hours thus spent and no university could be prevailed upon, doubtless, to give credit for it, but this fact did not disturb us and the writer will outline the happenings of the next few laboratory periods. After nu-

merous trials, we evolved a piece of apparatus embodying the features that were decided to be necessary and, although crude, it was put to a test without delay. The students without exception were interested now to see whether or not the problem could



—Multimeter—

be solved by an apparatus of this kind and close questioning revealed that the problem before the house was *well understood.* The accompanying cut will show the features of the apparatus as used. The flash A was arranged with a side tube closed with a stopper of such a nature, that when turned in one direction the aperature would be tightly closed and when turned 180° it would be open. A weighed piece of zinc was placed in the side tube T and the flask filled with moderately concentrated hydrochloric acid. All connecting tubes were filled with acid and the stopcock R closed and vessel B drained of all acid and then stopcock closed. Opening Q, the apparatus was ready to

function. The flask A was tipped slightly until zinc fell over into the acid in flask A and the hydrogen formed forced the acid from A into B where it was collected until reaction ceased. The manometer at flask A was then consulted and flasks raised and lowered until manometer indicated same pressure in both sides of the tube. Stopcock Q was then closed and the acid drained from B and accurately measured by draining same into a graduated 250 cc flask, and since it did not entirely fill the flask, the flask was then filled up to the mark with distilled water from the burette. The difference between the amount of water necessary and the 250 cc was the number of cc of gas formed by the given weight of zinc. The temperature of the thermometer in flask A was read and the barometric pressure was taken. The gas was reduced to standard conditions of pressure and temperature and to dryness by employing a chart to do the mechanical work of multiplying and dividing, using the usual combination of Boyle's and Charles' laws. This chart gives the value of one cubic centimeter of a gas changed from a given temperature to the zero and from any given pressure to the 760 mm and from wet to dry and from mercury pressure as the barometer gives it under the conditions to what it should be if the barometer mercury were at zero degrees. All of this being considered the value of one centimeter was given and this value multiplied by the amount of acid passing over this gave the number of centimeters of gas produced by the given weight of zinc. This number multiplied by the weight of one centimeter of hydrogen .00009 grams gave the weight of hydrogen obtained from the given amount of zinc and then by using the formula, Weight of H:Weight of Zn::1.008:X.

The computations and the experiment were performed in two hours, and the experiment repeated three times during this time with an average result of about 33, a rather small error for the length of time consumed.

This result was then related to the atomic weights by means of the valence, and the laws of Boyle and Charles reviewed and the knowledge of logarithims and the computation by their aid reviewed. We believe the students obtained some mental training in this process and for weeks afterward new suggestions kept coming in for new designs of our instrument and new suggestions as to the uses to which the same instrument might be put in other well known chemical operations. The writer may discuss some of these in a later paper. The little chart mentioned may be obtained from the Central Scientific Co., Chicago, we believe by simply writing them and requesting the same. We believe they do not charge for them.

THE RELATION BETWEEN THINKING AND MEMORIZATION IN MATHEMATICS.

By E. W. Atkins,

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Not long ago, it was generally held that the chief value which any course of study affords is that of training the mind. The disciplinary aim thus influenced to a very large extent both the content and methods of teaching. A little later, when students could not take all the subjects which the school offered and when as a result the value of specific subjects was being called into question, it was the custom merely to state that one subject was valuable because it offered good opportunity for training of the memory; another because it taught the student to think, and others because they were of a practical nature, etc. Everything went well until specific values were assigned to certain subjects. Then discussion arose over the values assigned. One common distinction which has been made is that of listing one group of subjects, as being valuable for training of the memory, and another as being valuable for training students to think—as if thinking and memory were separate processes. Thus, the distinction between memory and thinking has been made in the past and is still being made.

During the past few years this distinction has been made in most subjects, to some extent, but to a larger extent in the field of mathematics. Of late, teachers of mathematics have been emphasizing the fact that one of the cheif values of mathematical training is that it trains the student to think. In this connection Schultze says:

> "The principal value of mathematical study arises from the fact that it exercises the reasoning power more, and claims from the memory less, than any other secondary school subject. The study of mathematics should result in the development of power, rather than in the acquisition of facts. Not he who knows a great many mathematical facts is a good mathematician, but he who can apply these facts intelligently, who can discover facts that are new to him, and who can reconstruct those which he has forgotten."

Schultze seems greatly opposed to the use of memory in mathematics. He is willing to admit, however, that a lot of the training which the students have been getting is purely memory. Concerning memory he says:

> "In the preceding paragraph it was pointed out that mechanical memorizing is a perfectly proper method of studying the most elementary, the most fundamental facts, which are of frequent application. This is possibly the reason why the teaching is far more effective in the lower grades than later on. In more advanced work, the very nature of the subjects makes mere memorizing ineffective.
>
> "Our high schools, however, not only encourage memorization but some-

times almost force the student to adopt this as the only mode of study, for only by memorizing can he hope to satisfy the immediate demands of the school.

"The daily rations of mental food that the student has to swallow give him no choice; there is no time for thought, for meditation, for judicious study; he *must* memorize. Moreover, the character of the studies leads him to mechanical work, for in spite of the vigorous denials of our pedagogues, the greater part of the curriculum is informational. It is knowledge, and not power, that is emphasized in most of the studies, and even subjects which by their very nature should be mastered by thinking are often made informational. For the informational method produces much quicker and more spectacular results than the slow judicious mode of study. What a fine display of learning students can make if they have been cramming conscientiously! How high the percentage they can secure in examinations! True, the after effects are sad, but who cares? As long as the boy can talk glibly about complex economic problems in terms which he does not understand, we are satisfied. What does it matter, that a year later he has not the remotest inkling of the subject, that he cannot discuss intelligently the simplest new problem that may arise?

"Can we wonder that under such conditions the student never breaks away from his mechanical way of studying that he acquired in the elementary school? And can we wonder, too, that the results of our teaching become inferior in the higher grades of the grammar school, and especially so in the high school?"

One reason why there is such divergence of views concerning the relation between memorization and thinking is that the terms are not clearly defined. In the next few paragraphs, therefore, I shall attempt to define memory and thinking.

To begin with, just what do we mean by memory? James defines memory thus: "Memory proper is the knowledge of an event or fact, of which meantime we have not been thinking, with the additional consciousness that we have thought or experienced it before." This definition will include such experiences as seeing a formula in algebra and recognizing that it has been met once before—in geometry, say. This definition can also include the process of recalling a principle which is to be used in the solution of a problem or exercise, if consciousness is directed to the particular principle being applied. After some process has been carried through for a number of times and has been met in varying situations, it becomes so fixed that it may be carried on with little or no conscious direction being given to the particular process. However, for the present purpose it will be sufficient to include as memory *the process of recalling and recognizing some event or fact previously experienced.*

It will now be seen that memory is a much broader term than Schultze had in mind when he spoke of secondary mathematics making small claim on memory. However, Schultze admits that for the fundamental and elementary parts of mathematics mechanical memorizing is a perfectly proper method. Evidently, what he means is that before effective thinking will take place

some facts must be memorized without inter-relations or applications. This process of obtaining facts without inter-relations or applications is what is ordinarily called *rote memory*. When Schultze referred to mechanical memory he probably had reference to rote memory. Rote memory is distinguished from ordinary memory, not by the actual process involved, but by the fact that the material memorized has no *meaning*. No significance or connection is seen in the case of matreial memorized by this method. Memorizing the letters of the alphabet illustrates rote memory. No reason can be given why a certain symbol should be called *a* rather than *b*. True, in a few cases, some similarities can be pointed out, but even then the whole process is almost lacking in meaning. To the extent that the students find inter-relations and applications (which, in fact, constitute meaning) they are thinking.

Concerning what is meant by thinking, there seems to be more agreement and hence it will not be necessary to go into such detail in defining it. Thinking is problem solving. The process of problem solving or thinking is something like this: The individual is confronted with some situation which he *must* meet by a series of appropriate acts. (The need for the solution must be keenly felt before thinking takes place. Otherwise, the solution will be dodged or delayed.) When the problem becomes real to the individual, various solutions will be recalled from previous experiences with somewhat similar problems. These are each tried out to see if they will meet the confronting situation. Finally, some combination of experiences is found which will effect a solution to the problem. Then, and then only, may the thinking process be said to be complete.

At this point, a further restriction must be imposed. The particular combination of facts which is used to solve the confronting problem must be such that it is not entirely habitual. One process may now be entirely habitual, while a few years ago it required a great amount of thinking to carry it through at all. For example, a student in learning to transpose terms, first does so with much precaution. Later, however, he may perform this operation with little or no attention. The carrying out of such a process does not constitute thinking, because a problem has not been confronted. The mere matter of transposing terms after one is thoroughly skilled in the process is no longer a problem.

We are thus in a position to see that any problem solving or thinking must of necessity involve some sort of memory, for the

facts to be recombined are facts which in the past have been acquired and are now being recalled. From this it is also clear that we are not justified in saying that certain school subjects require a great amount of thinking, because they require little memory. True, memorization is one factor determining the complexity of the thinking involved in solving a problem of any sort, but we must look for other factors when we come to rating subjects according to the amount of thinking required.

Accordingly, almost any school subject as it is now taught calls for both memory and thinking. It is now generally agreed that training in some specific function trains that function only in specific lines. In other words, it is possible to develop the memory in any given line but the extra development will not manifest itself along all lines. In the same manner a student may be trained to think in special lines without having his ability to think in general improved. The problem which teachers have faced, then, has been that of developing in a limited manner the most desirable mental qualities in their students. And since, in general, college trained men do better thinking than those not so trained, it was but natural that teachers should single out thinking as the one quality which should be developed at the expense, if necessary, of other qualities. For the last twenty-five years mathematics teachers have been attempting to train their students to think. Most teachers of secondary as well as college mathematics now hold that their chief aim is to get their students to think. This is perfectly natural, as I have shown, and is probably as near their correct goal as any. At the same time, it is possible that in aiming directly at getting the student to think, the teacher may lose sight of some of the intermediate steps involved in the thinking process.

In mathematics it is exceedingly likely that teachers have gone so far in attempting to get their students to think that they have overlooked the function which memory performs. This is especially likely when we recall that not only mathematics teachers, but most other teachers as well, have been purposefully avoiding the use of memory in order that they might train their students to think better. This is a very serious mistake when we recall that the effectiveness of the thinking process depends in a large measure upon the number and clearness of facts at the disposal of the student. In fact, it would be impossible to train a student to think, unless he made some application of facts when he had obtained them. The thinking of a child differs from that of an

adult, not in kind, but in respect to the number of facts at his disposal. With the facts which a child has at his disposal, his conclusions are as reasonable as those of an adult. The difference between the two is due to the more extended experience of the adult.

If students must get the facts before they can think, it may then be asked just what relation does what we may call fact-gathering bear to the process of thinking? As a matter of fact, they are not entirely separate, for one always gains a bit of information when a problem is solved. Furthermore, the information thus obtained is of more immediate service and is retained better than that obtained by rote memory. It may be asked, then, why not obtain all facts by this method? This seems to be what teachers of mathematics have had in mind, even though the students frequently fall far short of it. Such a process is theoretically sound. A student might conceivably obtain all his information by building, piece-meal fashion, bits of information which he acquires from time to time. Such a process, however, meets the practical difficulty of lack of time. It would be perfectly possible for a student of physics to discover for himself each of the principles used. But such a process would take so long that he would not have time for applications, which are new to men of science, in general. What is done then is to give a great bulk of material as pure fact with little or no demonstration and require the student to accept this in place of actual first-hand experience.

It is desirable, of course, that the students get as much of the information as possible as a result of thinking. Yet, because of the rudimentary nature of some of the subject matter, or for lack of time, it may still be necessary and desirable to rely upon rote memory in some cases. If some of the fundamental principles—especially those which can hardly be proved or demonstrated—are memorized, it is possible that the student may be better able to do efficient thinking later when he goes to apply these memorized facts and finds them ready for use. Also, in view of the fact that a large share of the student's concern is with information gathering, it is probably well that he be required, at times, to state in a general way the facts and principles which have been acquired. By this method he will be able to see just what tools he has ready for use.

If a person is to do efficient carpenter work, he must have the proper tools. Not only must he have tools for the different types of work, but he must have these tools in first class condition, if

he is to work efficiently. The same is true with a student. If he is to think effectively, he must have the proper tools and have them in proper condition. The thinking which students have usually been required to do in class has been incomplete in one respect. Ordinarily, a principle is learned from the teacher's explanation or by working a few problems involving this principle, or both. This type of training will result in the student becoming—in the words of one mathematics instructor—"familiar with the principle." Now, what the students need in order to do efficient thinking, is not mere familiarity with a number of principles when these are recalled for him. A mere feeling of familiarity not only does not insure recall but causes ineffective thinking, due to hazy images. If thinking is to be effective, the tools, images or concepts must be definite and clear cut. The student must have the principle so thoroughly fixed that when he feels the need for this particular principle in problem solving, he will not only be "familiar" with it, but will have it absolutely under his control. For example, if the process of factoring the difference of two cubes is to be used as a tool in solving problems, the student must be able to recall in exact terminology this principle. A mere feeling of familiarity will not suffice in such a case.

If the student is to have processes, principles, and facts clear cut and definite instead of hazy as a result of the feeling of familiarity, he should have practice in recalling them. This practice in recall should be given immediately after a principle has been taken up in class. Of course, the principles will become clearer and more definite with additional applications but the ordinary class is usually crowded for time and it may be necessary to have the practice in recall given as merely drill in recall. At any rate, the student should have some practice in recall of some sort if he is to get principles and processes clear cut.

After having accepted as a fact that students of mathematics must of necessity use memory in their work, we are still faced with the fact that so many of them rely upon memory almost entirely. What factors in the student and in the school are responsible for the student's using an ineffective method? What causes the student to rely so much upon memory, instead of thinking when teachers constantly urge the use of the latter?

First, as Schultze has pointed out, memory is and should be used almost exclusively in the elementary grades. Yet, with the more advanced work, this method is insufficient. The student,

sometimes, when entering secondary or college mathematics, is more apt to try to memorize solutions to fit typical problems than to determine the method after meeting the problem. Students soon change their method of study from that of trying to memorize *all* the subject to that of memorizing only key portions. This is fortunate for them—especially so, if they, themselves, select the key solutions which they memorize. However, it is frequently easier for them to memorize solutions favored by instructors than to rely upon their own judgment.

The student is encouraged in thus relying entirely upon memory by the fact that his success or failure depends, very largely, upon the number of facts he can muster for examination. He soon learns that by carefully cramming, he is able to produce all that is required to pass the examination and this is all he cares. In fact, with some students it is considered a point in their favor to succeed in passing an examination with the least possible store of facts and principles. Other students may carefully go into the subject, may do infinitely more thinking and yet receive the same, or even a lower, mark on examination. It is very natural for such students to feel that they have not been properly rewarded for their extra work. Such a condition tends to cause the students to seek marks instead of mastering the subject and in seeking marks to use the most effective method, which, under the present system of examination, is that of memorization. The *lack of proper proportion* in giving marks to students, using different methods, at least, fails to convince the students that they should not rely entirely upon memorization. Far from convincing the student to the contrary, *the school frequently almost forces the student to memorize in some of the work.* The school makes such strenuous demands for results, for results immediately, and for results in so many different subjects, that the natural thing for the student to do is to get the results as easily as possible. When confronted with this situation, the student finds memory very handy, in view of the fact that he has relied upon it so much during his elementary work. Such a condition is especially likely to result with the present examination system.

Second, the method used in class room is such that students tend to memorize what they do get. The teacher is usually exceedingly anxious "to see signs of life" in his class. The students frequently meet this expectation by a show of facts and principles which have been committed to memory. Also the teacher, in his anxiety for results—and for his students to make a good showing on examination—usually feels it his duty to show

the students exactly what parts are likely to be needed for later work. Such aid causes the student to put too much confidence in the words of the instructor—even going so far as to memorize the principles which he stresses.

Further, the textbooks themselves are written so that formulae and principles to be applied are easily memorized without necessarily getting the inter-relations at all. It is not implied that the writers of the texts intended that such use be made of topical arrangements, differences in type, etc. They evidently intended that the student would do a certain amount of thinking in arriving at a certain principle and that for purposes of review he would find the arrangement of the text favorable. Such is the condition which *should* exist, but students are too likely to rely too much on mechanical aids for review and use them in place of the text proper. The older custom of having a number of type problems has been discontinued for this very reason. They were intended to be used only occasionally but the students came to rely upon them too much.

There is still a third factor, which while limited neither to students of mathematics nor to students at all, yet plays a very important part in determining the student's general attitude toward the school as a whole. Each person—if he is satisfied—has some characteristic or accomplishment which he feels entitles him to his "place in the sun." *A certain amount of satisfaction must be attached to any work if the individual is to really put forth effort in that direction.* Dissatisfaction is certain to result when a person fails to see that what he is doing is really getting him somewhere. What he cares for is to know that others approve of the particular work he is carrying on. Of course, a large amount of work is carried on, with little or no reward in the form of approval, but then the individual either classes it as drudgery or else he performs it with the vague hope that in the future the importance of the performance in question will be seen. It, therefore, happens that if a person is engaged in work the results of which are not immediately obvious, he is apt to tire easily and care little for its completion. He is still more likely to seek some other line of work in which the rewards are either more apparent or else seem more to be desired. In any case, it is certain that if a person is to take an active interest in the work he is doing *he must get at least a minimum of satisfaction from doing it.* The student is certainly no exception to this rule. Each student has some point or line along which he feels that he is

making noticeable headway. With some students high grades are the things to be most desired in college; others feel that if they can carry an excessive amount of work that their task is noble; others single out some special subject and feel satisfied if they are making headway in that even though they may have to drag along in other subjects; others cannot obtain from the schoolroom the satisfaction which is demanded before effort is put forth and turn to outside activities, athletics, social events, etc.; and still others may be able to get satisfaction from all their work as well as outside activities, etc. In each case, no matter what the medium of satisfaction, there is at least one line along which the student feels he is making headway. And, as I have said before, if it is difficult for a student to see that he is making headway, it is difficult for him to put forth proper effort.

The connection between this and the thinking process is, that a student can hardly see that he is making headway in thinking. What is likely to follow, then, is that the student will perform the required tasks as one does drudgery merely in order to "pass inspection." To be more specific, he is apt to memorize, instead of think, because he can secure the same or more approval and experience the same feeling of success. For this reason ability to think is rarely made the student's line of headway. He is apt to turn to something else which will give him the required feeling of making headway, and when he makes this turn, to substitute memorization for thinking.

If, as I have indicated, memory and thinking take place together and students tend to prefer memory in place of thinking, it may be asked under what conditions does thinking of the highest order take place? Thinking consists of recombining different bits of past experiences with the purpose of meeting some confronting situation. Thinking is of high or low order, depending upon the relation between the tools in hand—experience—and the problem to be solved. Thinking of a high order results when a problem is felt long before one has the experience or tools necessary to solve it. If one can feel a problem and spend a long time getting tools to be used in solving it, the thinking is of a high order. On the other hand, thinking of a low order results when one fails to see a problem until he is in the midst of it and then sets about to effect some solution by means of whatever experiences happen to occur to him at the instant. Hence, if a student is to do thinking of a high order, he must see a problem, set about to get the necessary tools, and then combine the tools properly.

The significance of this for mathematics is this: If mathematics is to remain a subject valuable for training students to think, *care must be taken to see that problems are felt far in advance of their actual solution and that tools for their solution are acquired with the problem in mind.* In other words, thinking of a high order must result if mathematics is to continue to have high value as a subject for training students to think.

At present, such a warning is in order because of changes in school conditions. When mathematics earned its place as a subject valuable for the training it gave in thinking, the conditions under which this training was given were far different from what they are today.

One of the most significant changes has been in the size of the class. A number of important changes have been due directly to this increase in size of classes. When classes consisted of few students, or perhaps only one student, it was possible to do much more towards getting the student to think than at present. First, the teacher could adjust the problems to fit the student's ability better than at present and thus secure thinking of a higher order. And for that matter, the teacher doubtless knew the student's ability better than it is known today. Second, the examination was not so likely to cause trouble as at present. It was not so necessary, for the teacher had a pretty fair estimate of the student's ability before the examination. Hence the student could not secure high standing as a result of the examination alone as he can today. A third result is directly traceable to change from individual to group instruction. Formerly, the student looked to the instructor for approval. In fact, he and the instructor were very close together. Now, however, the student looks chiefly to his fellow students for approval. If he gets it from them, he is not so much concerned with the approval of the instructor. This would not be of much consequence, were it not for the fact that the student's associates are easier satisfied, so far as class work is concerned, than the instructor. A student can meet the demands of his associates, so far as class work is concerned, by a minimum of thinking and may even substitute memory, since he finds memorizing easier than thinking. And, besides, he can meet the demands of his group better by outside activities than by classroom activities. The result is that he feels that his point for making headway is not in the schoolroom, and hence puts forth less effort now than formerly.

Besides the change from small groups to larger groups, one

finds a change in the nature of the textbooks and methods of instruction in general. With the change from small to large groups, it becomes necessary to give the material in more digested form. This means that the subject matter must be within the grasp of the weakest student. Hence there is a tendency for the textbooks to concentrate on a few principles which will be used by everyone instead of being more complete and leaving to the teacher the task of omitting portions not needed by the individuals of the particular group. This change in the nature of the text and in the type of instruction has resulted in the student not being asked to do as much in a given subject. He gets a smattering of a number of subjects instead of getting a few subjects well. The whole change in conditions encourages the substitution of mere memory for thinking.

To meet this change in conditions and retain for mathematics its high value for training students to think, two aims should be held with more firmness than has been the case in the past. First, *the students should do a greater amount of effective memorizing.* They should become skilled in the use of a few fundamental principles, instead of merely becoming familiar with a larger number. Second, *more far-reaching problems should be given*—thus making it necessary that the student seek the tools—specific manipulation processes—while he has the major problem in mind.

It is not to be understood that because attention has been directed towards mathematics that mathematics is alone in this matter. On the contrary, most school subjects are facing these same problems to some extent, and what I have said can in many cases be applied equally well to other school subjects. The way in which teachers, generally, and mathematics teachers, specifically, meet this situation will have much to do with the effectiveness of the thinking done by their students.

GRADUATES OF WOMEN'S COLLEGES BECOME TEACHERS.

The teaching profession still leads in attracting women college graduates, according to a study of the occupations of recent graduates of five women's colleges made by the News-Bulletin of the Bureau of Vocational Information. Of 1,305 girls who were graduated in 1922 from Barnard, Goucher, Radcliffe, Smith, and Wellesley, 556 are reported to be gainfully employed, and more than half of this number, or 355, are teaching. The second largest group of graduates numbering 156, are engaged in graduate and professional study, and since it is probable that many of these are taking courses in schools of education, it may be concluded that the number of graduates who have been attracted to the teaching profession is even greater than the present report shows.—[*School Life.*

A LABORATORY PROJECT IN HIGH SCHOOL BIOLOGY.

By Francis D. Curtis,

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The class-activity here described under the title of "Laboratory Project," obviously lacks the degree of pupil motivation which characterize the true project; yet it is more than a "problem" or an "intellectual difficulty." It is here called "project" for want of a more accurate term.

It is presented about as indicated below in the beginning classes in biology early in the course. The pupils have previously had a little laboratory work upon the cell, the epidermis of the onion, and epithelial cells of the mouth, with test and reference work on the cell following and correlating with this laboratory work; they have learned how to use the compound microscope, having examined the above cells, the scales on a moth-wing, and a number of other "practice "objects, and have learned how to make slides from fresh material.

In front of each student's chair on the laboratory table is placed before class a small beaker containing a straw-culture, which the instructor has previously found to be rich in paramecia or other protozoa; a medicine dropper; a slide and coverglass; a compound microscope; a small wisp of absorbent cotton.

As soon as the members of the class come into the room their curiosity is aroused at once by the beakers containing the dark-colored, iridescent-coated, foul-smelling liquid with its rotting hay, and there is sure to be considerable speculation concerning their purpose there.

When it is time for the class to be called, the teacher takes his place at his desk to await developments. Somebody is certain at once to ask, "What's in these beakers?"

Teacher: "A straw culture." (This remark at this stage of the course means nothing to the class.)

Pupils: "What's that? What's it for? What are we going to do with it?" "What makes it smell so?" "What causes the black in it?" etc.

Teacher: "I am wondering about some of those same points, myself."

At this point, if not sooner, the sight of the materials is sure to suggest making a slide. As soon as the teacher sees somebody preparing to do this he suggests to the pupil, in the presence of the class, of course, that he take some of the material near the surface of the beaker. Everybody immediately makes a

slide and, according to previous instructions, focuses it under the low-power lens. Exclamations of interest and wonder are heard from all sides (the class should be very informal so as to permit entire freedom). After the general incident surprise, and interest have had a minute or so to subside, somebody is sure to ask, "What are these?"

Teacher (still remaining in his seat at his desk): "These? What?"

Pupil: "I don't know what they are? I don't know what to call them; I never saw anything like them before."

Teacher: "What do they look like?"

Pupil: "I can't describe them. Won't you look at them?"

Teacher: "No. I would rather have you describe them. Better still, if you can, draw a good enough sketch of them that I can recognize them."

Pupil: "They're too little under 'low', and when I look at them under 'high' they go by so fast I can't make them out."

Teacher: "Put a very little wisp of that cotton under the slide of your cover glass. Frequently, though you may have to make several trials, you can limit the activities of the small organisms with the cotton fibers so as to keep them almost stationary under the microscope long enough to examine them carefully. If this does not succeed try a drop of this ether placed at the edge of the cover-glass."

Everybody of course follows these suggestions now; some are sure to have success and their exclamations of delight stimulate the rest to succeed in penning up one or more of the animals likewise.

At this stage, the team-work with the class, as a whole, practically ceases and the teacher must direct his attention from his desk to the questions of individuals in their separate studies. Everybody is practically sure to make some sort of sketch of the paramecium; questions and remarks like the following are sure to be heard:

Pupil: "What are these things which wiggle at the front of it?" T. "What do they look like?" P. "I don't know—(after a further careful examination)—hairs. What are they for?" T. "I'd rather not answer just yet. Let's find out more about it."

P. "I see how it moves, now." T. "How?" P. "It turns over and over as it swims—like a corkscrew."

P. "There are several other different looking things. Here's

a funnel on a stem that moves." T. "Can you sketch them?"

T. (To the class): "If you are going to ask me to tell you later what any of the organisms you are studying are, you must be sure to make sketches which are recognizable, in outline at least, and as complete otherwise as you can."

About a quarter of an hour before the close of the laboratory period the teacher suggests that the members of the class may like to compare their drawings. This comparison leads to many discussions and differences of opinion regarding features and various points, which are referred back to the slides and the microscopes for verification.

Just before the close of the period the teacher, (who has declined to look at any of the drawings up to this time) walks around the class glancing at the drawings. He postpones the answering of any of the questions which have arisen regarding the work during the period, but makes it a point to question the accuracy of observation here and there, being careful, however, not to indicate any errors which he can not reasonably expect the pupil to correct with a further study of his slide. He finally announces, "Your drawings convince me that you have found some protozoa."

P. "What are *they?*"

T. "There's not time enough left today to tell you about them; in fact, at this point I'd much rather not tell you about them at all. Wouldn't you like to find out something more about them for yourselves, before we discuss them in class?"

Most of the pupils are eager to do so. Somebody is sure to search the index of a convenient text, and to announce the fact that he has found a reference. Since the class is already familiar with their library reference facilities, the pupils suggest the titles of several possible sources of information. The teacher approves, "Very well, then. I shall be interested tomorrow in hearing what the class can tell *me* about protozoa."

The following class periods are devoted to the extent permitted by the time schedule, to pupil-discussions of the material they have collected concerning the paramecium (which most of them will have recognized from their drawings) and other protozoa, and to the integration of the further little individual student investigations which have been prompted by their reference readings and by their desire to examine other cultures.

The teacher finally summarizes the results of all the class investigations, supplying whatever material he considers necessary and desirable, in addition to that which the class have unearthed.

LABOR SAVING DEVICES.

By F. A. Hay,

Adrian College, Adrian, Mich.

In the up-to-date factory every piece of equipment is judged by its efficiency. Methods that were used yesterday, and were successful, are discarded today because some one has found a simpler or an easier way of doing the same work. Not a moment is lost, not a useless movement is made, because in the business world time means money.

Have the schools and colleges been as careful in utilizing time? Are the chemical laboratories arranged so that the student can do his best work in the shortest time, or are the old methods still in use?

Not every school is so fortunate as to have an unlimited amount of money for buying equipment, but every school should be able to supply the few pieces of apparatus that are most useful to the students. What these pieces of apparatus are is the problem that we have been trying to solve.

A visitor to the laboratory may not notice at first glance that the apparatus is different from that usually found in a chemical laboratory. But soon he will see that the student has all the chemicals he needs for many weeks within a few steps of his desk. This is possible because a rack, turning upon a central axis, is used. In this rack are many bottles. Each bottle is numbered, and just below the rack, a typewritten list protected by a transparent cover, is placed. A glance at the list, a turn of the rack, and the material is ready for use. As the bottle is returned to the rack at once, the next student is able to get it without delay.

Much time is lost in many laboratories in weighing chemicals. That process is shortened here by the use of a scale clamped to the standard of the chemical rack. The scale-pan being of horn or glass, is easily cleaned. As the pointer indicates at once the total weight in grams and decigrams, precious minutes ordinarily used in counting up the small weights are saved. The degree of accuracy is sufficient for all work except that of experiments requiring quantitative results.

Even in such a trivial matter as that of connecting tubes of different sizes, time can be economized. Anyone who has tried to find exactly the right rubber stopper for a U tube, or other connection requiring a small size, knows how exasperating such a search may be. This difficulty is overcome in

this way: A piece of glass tubing a little longer than needed is pulled out at both ends. A short piece of rubber tubing is put over one of the ends, the usual rubber connecting tube is used at the other end and the U tube, easily and quickly closed, is connected with the delivery tube.

Perhaps the greatest contribution that Professor Jones has made to chemical apparatus is his multimeter. Most teachers consider the Kipp apparatus a necessary evil. It is useful but it has the bad habit of leaking just at the wrong time, and it must be entirely cleaned out after an experiment before it can be used again. Not so with the multimeter. It is possible by means of this apparatus to generate several gases such as hydrogen, hydrogen sulphide, and carbon dioxide successively by simply changing the material in the reagent tube. The spent acid, because it is usually heavier, sinks to the bottom of the apparatus and can be drawn off by opening the stop-cock. Fresh acid may be poured into the opposite flask. The new material is placed in the container c, the tube is then lowered into place, and the demonstrator is ready to show the evolution of a different gas. In the same way several gases produced by the action of water on the chemical may be made in a laboratory period. At the end of the experiment the container c is lifted out and all possibility of mingling of acid and solid is prevented.

The apparatus can be used also in determining the equivalent of hydrogen, the weight of a liter of oxygen, percentage of oxygen in the air, vapor pressure of liquids, proof of Charles' law, and other experiments, usually given in a course in chemistry. The experiment for the equivalent of hydrogen can be performed two or three times during a laboratory period, if the zinc has been carefully weighed out before the time for the demonstration. The student records the weights and volumes, works out the problem, and from the average result obtains an accurate estimate of the equivalent of hydrogen. As the student is required to write out all demonstrations before the next time scheduled for laboratory work, his impressions are permanently fixed.

Another labor saving device that appeals to those who think that the time spent in multiplication and division could be used more profitably in some other way, is the "Gas Volume Reduction Chart." This chart is simple and inexpensive but by its use the labor of solving gas problems is greatly reduced. Two concentric cardboard disks, one slightly larger than the other, are fastened at the center but are free to move about the

axis. On the edge of the larger disk are marked the barometric readings, on the smaller disk, the temperature readings. To use the chart, the observed temperature is placed opposite the observed barometric reading in millimeters. At once, another scale records the corrected volume of one cubic centimeter of the gas collected over water. It is then a simple matter to multiply the corrected volume of one c. c. by the number of c. c. to obtain the corrected volume of the total quantity of gas.

"A scale giving the logarithms of the volume factor is provided for calculations by logarithms. The slide-slide scale along the upper edge is provided for simple multiplication."

By the use of such devices and apparatus it is believed that the student can understand more quickly and more easily the real purpose of the experiment than he can when much of his time and thought is taken up by the mechanical processes. As the success of an experiment depends upon understanding the principles involved, the student whose attention is concentrated on the experiment itself should grasp the fundamental purpose of that experiment with comparatively little difficulty.

MANIPULATION OF GAS HOLDERS BY ELEMENTARY STUDENTS.

By C. A. Broutlecht.

University of Maine, Orono.

In supplying gases such as oxygen, hydrogen and practically all other gases which are insoluble in water to elementary chemistry students, where the gas is not available in small cylinders or can be drawn from pipe lines, the writer has found the following procedure very satisfactory. The ordinary gas holder (Berzelius and Papy type) of twenty or forty liters capacity, easily portable from lecture room to laboratory and easily handled by the students, is filled from a steel cylinder or with the desired gas generated in a lecture. A rubber tube, with a piece of heavy glass tubing drawn to the proper size opening to yield the proper flowage of gas inserted near the end, is attached to the gas outlet tube of the holder. The other end of the tube is attached to a glass tube fastened under the opening of a tray in a pneumatic trough. To secure proper pressure supply, a 2.5 l. bottle is filled with water and inverted in the water in the pressure tube of the holder. With the cock of the pressure tube open during the class interval, upon opening the gas outlet cock completely, the student can withdraw the quantity of gas desired quickly by downward displacement of water in bottles over the opening of the outlet tube. This requires less than a minute and there is little, if any, waste. When the pressure water bottle is empty, a student desiring some of the gas fills and replaces it. With such procedure, it is possible to compute the quantity of gas required per student or class per exercise and provide for it, certain that there will be a sufficient supply. Using gas cylinders or gas holders without such arrangements, it is a difficult matter to avoid waste. The small amount of time required to fit up the holder is well repaid in saving of time, material and the patience of the instructor.

PRELIMINARY REPORT OF COMMITTEE ON CHEMICAL EDUCATION RELATIVE TO THE CORRELATION OF HIGH SCHOOL AND COLLEGE CHEMISTRY[1]

By NEIL E. GORDON

Chairman of National Committee on Chemical Education of The American Chemical Society.

Editor's Note: This list of topics for "A Standard Minimum High School Course in Chemistry" is being published in order to get it before the greatest possible number of teachers of chemistry during the coming school year. Sub-committees will be formed where necessary in order that this report may be carried to completion in the least possible time. The chairman of each sub-committee will organize his own particular locality and arrange for receiving and tabulating criticisms. It is hoped that chairmen of all sub-committees may have their reports in the hands of the national chairman so that the national committee on chemical education may make a final report at the Washington Spring Meeting of the American Chemical Society.

Although this report is printed primarily for teachers, the committee will count it a privilege to receive criticisms from all who are interested in the teaching of high school chemistry.

(The Editor for Chemistry of School Science and Mathematics will be glad to receive marked copies of this article clipped from this number from anyone who wishes to criticize it. Draw a line through anything you would omit and put additional topics on a sheet of paper referring them to their proper places by number and heading as:

The Committee[1] on Chemical Education of the American Chemical Society, which has been charged, during the past year, with correlating courses of high school and college chemistry, had its first official session at New Haven at the Spring Meeting of the American Chemical Society, in April, 1923. The Committee decided that the four following objectives would help most in solving the correlation problem:

1. To encourage the teaching of chemistry in the high school.
2. To have such a course given in high school that it would answer for students who go to college as well as for students who do not go to college.
3. To outline a minimum high school chemistry course, taking into account both content and method.
4. To have colleges recognize high school chemistry, at least to the degree of having a different course for those students who have had the said outlined high school course.

These four points were taken before the Section of Chemical Education and after some discussion were approved, and hence the committee began to make plans for their development. The

[1]Reprinted by permission from the Nov. 1923 issue of the JOURNAL of INDUSTRIAL and ENGINEERING CHEMISTRY.

[2]Neil E. Gordon, Chairman, University of Maryland, College Park, Md.
L. W. Mattern, McKinley Manual Training School, Washington, D. C.
J. R. Kuebler, Shortridge High School, Indianapolis, Ind.
W. Segerbloom, The Phillips Exeter Academy, Exeter, N. H.
Prof. L. C. Newell, Boston University, Boston, Mass.
Prof. B. S. Hopkins, University of Illinois, Urbana, Ill.
Prof. R. E. Swain, Leland Stanford University, Stanford, Calif.
Dr. R. E. Rose, E. I. DuPont De Nemours & Co., Wilmington, Del.
Dr. William D. Richardson, Swift & Co., Chief Chemist, Chicago, Ill.
Dr. Walter Schmidt, Western Precipitation Company, Los Angeles, Calif.

most direct point of contact was the preparation of the high school outline which the committee has termed "A Standard *Minimum* High School Course in Chemistry."

The following objectives have governed the Committee in their work:

1. To prepare an outline for High School Chemistry which is satisfactory for students who wish to get a general knowledge of chemistry as well as those who are going to college.
2. To list only the minimum essential topics which are common to all localities so that the high school teacher will have time in developing the course to supplement these minimum topics with material which he considers especially suitable for his locality or for the future work of his students. See end of this report.
3. To prepare an outline which would cover the essentials of any state requirements.
4. To prepare an outline which would be in tune with the syllabus of the college entrance examination board.

It is anticipation of the Committee that the following objectives will govern the High School teacher in developing the outline:

1. To show the service of chemistry to the home, to health, to medicine, to agriculture, to industry, etc. In a word, to show the service of chemistry to the nation.
2. To develop this service—chemistry around these minimum standard topics and in doing so to see that these minimum requirements are so well taught that they may be built upon as a foundation in college.
3. To use his own order of developing the listed topics.
4. To train the student in keen observation and exact reasoning.
5. To develop a careful correlation between recitation and experiment.
6. To encourage students to keep note books which shall be an accurate record of laboratory experience, expressed in concise, clear English.
7. To encourage chemistry being placed in the fourth year of high school, after the students have had a year of general science, and a year of biological science or physics or preferably both.
8. To build upon the earlier science courses and knit them together in the best possible manner.
9. To encourage students to use reference books in addition to their text book.
10. To help pupils to find themselves, i. e. to discover whether they have an aptitude for further study in chemistry or applied science, and if so to encourage such students to continue their study of science in university or technical school.
11. To stress throughout the course the general principles involved in the specific cases studied.

TOPICS FOR A STANDARD MINIMUM HIGH SCHOOL COURSE IN CHEMISTRY.

1. *Water.*
   (a) General Distribution.
   (b) Physical properties: color, odor, taste, density, boiling point, freezing point.
   (c) Solution: solvent, solute, saturated solution, process of solution, degrees of solubility, factors affecting the solubility of a substance; suspensions.
   (d) Impurities in water: what constitute impurities; purification from suspended matter; purification by boiling, distillation or filtration.

(e) Crystallization: water vapor, water of hydration, deliquescence and efflorescence.

(f) Chemical properties: Synthesis by weight and volume; quantitative composition by synthesis from ? ? ? contrast of physical and chemical change, contrast of elements and compounds; stability of water; interaction of water with active metals; order of activity, interaction with oxides.

2. *Oxygen.*

(a) Preparation.
Electrolysis of water.
Industrial.
Potassium chlorate (use of Catalytic agent.)

(b) Properties.
Physical: color, odor, solubility in water, weight relative to air, weight of 22:4 liters.
Chemical: Tendency to form oxides in air and in oxygen, explanation of oxidation and combustion, kindling temperature.

(c) Uses (practical) necessary to life.

(d) Ozone briefly as to its preparation, properties and uses.

3. *Hydrogen.*

(a) Preparation.
Electrolysis of water.
Industrial.
Action of certain metals (i. e. sodium) on water.
Replacement in acids by metals.

(b) Properties.
Physical: as with oxygen.
Chemical: burns in air, reduction by hydrogen.

(c) Uses (practical) oxyhydrogen flame, balloons, hydrogenation of oils.

(d) Hydrogen peroxide briefly as to its preparation, properties and uses.

4. *Laws, Hypotheses, and Theories.*

(a) Law of conservation of mass.

(b) Law of definite composition (proportion).

(c) Atomic theory (simple treatment).

(d) The Law of Boyle and the Law of Charles, treated briefly with special reference to gases, not experimentally, but rather their application to the interpretation of change of volume.

(e) Law of Gay-Lussac and Avogadro's hypothesis.

5. *Symbols, Weight and Volume Relations.*

(a) Atomic weights (not their experimental derivation) especially in their use in performing simple chemical calculations.

(b) Molecular weights as explained by law of Gay-Lussac and Avogadro's hypothesis.

(c) Symbols and formulas (not their experimental derivation) especially their use in writing equations.

(d) Valence with special reference to writing formulas.

(e) Equations and their use in expressing chemical changes, including gravimetric and volumetric equations.

(f) Problems involving (1) percentage composition (2) weights of substances and volumes of gases concerned in chemical reactions, and (3) the laws of gases.

(g) The five kinds of chemical changes—Direct combination, Decomposition, Simple Replacement, Double Replacement, and Oxidation and Reduction.

(h) Formulas and writing of equations for reactions already studied.

6. *Air.*
   (a) Percentage of oxygen and nitrogen by weight and by volume.
   (b) Test for water vapor and CO_2
   (c) Liquid air.
   (d) Evidences that air is a mixture and not a compound.
7. *Nitrogen.*
   (a) Occurrence.
   (b) Properties.
      Physical.
      Chemical: nonsupporter of combustion, general inactivity, tests.
   (c) Nitrogen fixation as illustrated by plants, synthesis of NH_3, and oxides of nitrogen.
   (d) Uses (practical).
8. *Oxides of Nitrogen.*
   (a) Nitric oxide: Preparation, properties, tests and uses.
   (b) Nitrogen peroxide: Preparation, properties, tests and uses.
9. *Nitric Acid.*
   (a) Preparation.
      Industrial (from the air).
      Sodium Nitrate with sulphuric acid.
   (b) Properties.
      Chemical: action of dilute and concentrated nitric acid on copper and silver, test for nitric acid or a nitrate, decomposition products of different nitrates.
   (c) Uses, aqua regia, oxidizing agent, nitrocellulose industries, high explosives, briefly.
10. *Ammonia.*
   (a) Preparation
      (a) Decay of nitrogenous matter.
      (b) Industrial. Haber process.
      (c) Destructive distillation of soft coal.
      (d) Action of ammonium salt with non volatile base.
   (b) Properties.
      Physical.
      Chemical: basic character of water solution, ammonium radical, formation of ammonium salts, test.
   (c) Uses: refrigerating agent, preparation of ammonia water.
11. *Acids, Bases and Salts.*
   (a) Properties.
      General (taste, action on litmus, etc.)
   (b) Normal and molar solutions.
   (c) Activity of acids and bases.
   (d) Solutions conductors of electric current.
12. *Theory of Ionization* (treated briefly).
   (a) How theory explains electrolysis.
   (b) How theory explains neutralization.
   (c) Acid and base defined in terms of ions.
   (d) Atom and ion distinguished.
   (e) Chemical equilibrium.
   (f) Reversible reactions.
   (g) Why reactions go to completion.
   (h) Common ion effect.
13. *Sulfur.*
   (a) Occurrence.
   (b) Extraction: American method. (Frash method.)

(c) Allotropic forms: rhombic, prismatic and amorphous, flowers of sulfur.
(d) Properties. (Compare with oxygen.)
Chemical: direct combination with copper, iron, zinc.
(e) Uses: vulcanizing rubber, making matches, making sulfur dioxide.

14. *Oxides of Sulfur.*
(a) Sulfur dioxide.
Preparation: burning sulfur; roasting sulphide ores, action of an acid upon a sulfite.
Properties:
Physical.
Chemical: action with water. (Sulfurous anlydride test.)
Uses: bleaching, reducing agent.
(b) Sulfur trioxide.
Preparation. (Industrial.)
Catalysis as illustrated by its manufacture.
Properties, including test.
Uses.

15. *Sulfuric Acid.*
(a) Preparation.
Lead chamber process. Simpler chamber reactions only.
Contact process.
(b) Properties.
Physical: Specific gravity and boiling point.
Chemical: Affinity for water, action of dilute acid on metals and of concentrated acid on copper Compare with action of nitric acid on copper. Test for SO_4 ion.
(c) Uses: Preparation of other acids with reason for the same; manufacture of fertilizers; refining of petroleum.

16. *Hydrogen Sulfide.*
(a) Preparation: Ferrous sulfide and dilute hydrochloric or sulfuric acid.
(b) Properties.
Physical.
Chemical: combustion; action on metals; action on solutions of metallic salts.
(c) Uses; Precipitation of sulfides with special reference to testing for certain metals.

17. *Perodic Table for Classification Only.*
(a) The elements arranged in order of atomic weights.
(b) Relation of valence to group numbers.
(c) Gradual transition from metals to non-metals, in passing from Group I to Group II.
(d) Increase of metallic nature with increase of atomic weight within the group.

18. *Halogens.*
(A) Chlorine.
(a) Preparation: one industrial method, one laboratory method—oxidation of hydrochloric acid, using a chloride manganese dioxide, and H_2SO_4.
(b) Properties.
Physical.
Chemical: Direct combination with other elements to form chlorides, tests. Compare with oxygen.
(c) Uses: bleaching and disinfecting action.
(d) Compound.

Hydrochloric acid. (Gas and solution).
Preparation: a chloride and sulphuric acid.
Properties. Physical.
Chemical: a typical acid shown by taste, action on litmus and reaction with metals, test for chloride ion.
Uses.

(B) Bromine and Iodine.
(a) Preparation contrasted with chlorine.
(b) Comparison of physical and chemical properties of chlorine, bromine and iodine; relative replacement, tests.
(c) Uses of iodine.
(d) Position of the halogens in the periodic table.

19. *Carbon.*
(a) Occurrence.
General distribution.
Allotropic forms, diamond, graphite, amorphous forms.
(b) Commercial Preparation of useful forms: Graphite, Charcoal, Lampblack, Coke, Boneblack.
(c) Properties.
Physical.
Chemical: Affinity for oxygen, action with calcium and silicon.
(d) Uses: Common fuels, including carbon and carbon compounds. Operation of household stoves and furnaces, reduction by carbon, absorbent.

20. *Carbon Dioxide.*
(a) Occurrence: Relation to plant and animal life.
(b) Preparation: burning of carbon or a carbon compound.
Action of acid on a carbonate.
(c) Properties.
Physical.
Chemical: nonsupporter of combustion; action with soluble hydroxides; brief treatment of its solubility in water, its role in nature, plant growth and temporary hardness in water, test for carbonate ion.
(d) Uses: refrigerating, beverages, fire extinguishers, leavening agent in bread making.

21. *Carbon Monoxide.*
(a) Preparation (1) from oxalic acid.
(2) Reduction of carbon dioxide by carbon.
(b) Properties.
Physical.
Chemical: combustibility, reducing power, test.
(c) Uses: Reducing agent, industrially, constituent of water gas, coal gas, and producer gas.
(d) Illuminating and Fuel Gases: Manufacture and uses.

2. *Sodium.*
(a) Preparation.
Industrial preparation by electrolysis of Na OH.
(b) Properties.
Physical: Metallic luster, hardness, color, power to conduct heat and electricity.
Chemical: Flame test, action with water, action with chlorine.
(c) Compounds of Sodium.
Hydroxide: Commercial preparation (either lime soda process or electrolytic process) properties as typical base; neutralization, test for hydroxytion.

Use: Soap making, cleansing agent.
Chloride: Occurrence in sea water and mines. Laboratory preparation, uses: role in industry.
Carbonate: Preparation by Le Blanc and Solvay process. Properties, and uses (particularly industrial).
Acid Carbonate: Preparation (laboratory and industrial) properties, uses; baking powders.
Nitrate: Occurrence, properties, uses.

23. *Calcium Compounds.*
   (a) Carbonate:
   Occurrence: marble, limestone, shells.
   Properties: Solubility in water containing carbonic acid (temporary hard water); decomposition by heat; action with acids.
   Industrial uses: Building material, making of quicklime, flux in iron furnaces, glass.
   (b) Oxide: Preparation (industrial) properties, industrial uses.
   (c) Hydroxide: Preparation, properties, uses (mortar, its hardening)
   (d) Sulphate: Occurrence, properties, uses; permanently hard water and contrast with temporary.
   (e) Bleaching Powder: Commercial preparation; uses, bleaching disinfecting.
   (f) Calcium Phosphates: Preparation, uses, (fertilizers).
   (g) Fertilizers: Presence of potassium, nitrogen, and phosphorus as ingredients in respective compounds.

24. *Iron.*
   (a) Metallurgy (extraction from oxide ores. Blast furnace, pig iron.
   (b) Physical properties of cast iron.
   (c) Uses of cast iron; castings, etc.
   (d) Steel: Manufacture (Bessemer, open hearth and electrical processes); varieties of iron and steel with reference to their industrial uses.
   (e) Protective coatings to prevent corrosion of iron and steel; Tin (tin ware) Zinc (galvanized iron), nickel plate, enameled ware, paint.
   (f) Compounds of iron.
   Oxides: Occurrence and uses.
   Hydroxide: Preparation (laboratory) properties, uses.
   Sulfate: Preparation, properties, uses.
   Chlorides: (ferrous and ferric) Preparation (laboratory) properties, uses. Ferrous and ferric compounds: Oxidation and reduction of iron compounds; change of valence.

25. *Zinc.*
   (a) Metallurgy from oxide, carbonate and sulphide.
   (b) Properties.
   Physical.
   Chemical: action with dilute acids, electromotive series, primary cells.
   (c) Uses: Alloys.

26. *Aluminum.*
   (a) Metallurgy. Electrolytic process.
   (b) Properties.
   Physical.
   Chemical: action with H Cl and Na OH, amphoteric character.
   (c) Uses, utensils, alloys.
   (d) Compounds.
   Hydroxide: Preparation (laboratory); properties, uses: purification of water.

Sulfate: (alum) Preparation (laboratory) Properties and uses.

27. *Copper.*
   (a) Preparation (outline of process only with reference to iron).
   (b) Purification by electrolysis.
   (c) Electroplating.
   (d) Properties.
      Physical.
      Chemical: action with air and acids.
   (e) Uses. Electrical purposes, alloys.
   (f) Compounds of copper.
      Sulphate: Properties and uses: water purification, fungicide.

28. *Lead, Properties, Uses. Lead Compounds.*
   (a) Lead Monoxide: Preparation, properties, uses.
   (b) Basic Lead Carbonate: Industrial preparation, properties, uses, paint.

29. *Sources of Organic Compounds.*
   (a) Destructive distillation of wood; wood alcohol, acetic acid, charcoal.
   (b) Destructive distillation of coal; gas, ammonia, benzole, tar, coke.
   (c) Distillation and cracking of petroleum, gasoline, kerosene, vaseline, paraffin.

30. *Organic Compounds.*
   (a) Sugar.
   (b) Starch.
   (c) Acetic acid: Briefly.

Optional List.

Shall these topics be included? If so, to what extent? Opinions are solicited.

Energy Change.
Periodic Law.
Electrolysis.
Reacting Weights (not atomic).
Hydrogen peroxide.
Zinc Oxide.
Zinc sulfate.
Zinc Chloride.
Colloids.
Rare Gases of Air.
Arsenic.
Silver.
Other alloys than those contained in copper.
Alcohol.
Soap.
Phosphorus.
Mercury.
Electronic Structure of Matter.
Fehling's Solution.

LIST OF TOPICS FOR SUPPLEMENTARY WORK.[2]

Glass: Crown, flint, lead, special glasses, coloring of glass.

Clay Products: Brick, pottery, chinaware, porcelain.

Artificial Stone: Lime, plaster, mortar, hydraulic cement, concrete stucco, plaster of Paris.

Fertilizers: Problems of soil fertility, elements needed by growing plants and function of each. Photosynthesis and carbon dioxide cycle.

[2]Taken from Bulletin No. 26, on Reorganization of Science in Secondary Schools.

Nitrogen cycle and function of nitrogen fertilizers. Use of limestone and phosphate rock.

Coal: Composition and fuel values of different varieties. Distillation of coal tar, light oil, middle oil, heavy oil, tar, pitch. Relation to dyes and explosives.

Petroleum: Fractional distillation into burning oils, solvent oils, lubricants, paraffins. Problem of gasoline supply and possible exhaustion of petroleum.

Wood: Distillation of wood to produce methyl alcohol, acetone, acetic acid, charcoal.

Explosives: Black powder, nitroglycerine, dynamite, guncotton, trinitrotoluene. Relation to nitrogen fixation by arc, Haber and cyanide processes.

Paint: Varnish, etc. Oil paints and driers, varnish, shellac, copal. Linseed oil, oilcloth, linoleum.

Pigments: White lead, red lead, iron oxide, lead chromate, etc.

Textile Fibers: Natural and artificial silk. Wool: scouring, bleaching, felting, etc. Cotton: Bleaching, mercerizing, etc.

Dyeing: Direct and mordant dyes.

Cleansing Agents: By acid: Oxalic, hydrochloric. By alkalies.: Caustic soda, soap emulsification. By special solvents; Carbon tetrachlorid, benzene. Composition of trade-marked cleaning fluids.

Photography: Blue prints, plates, films, prints, toning, etc.

Food: Constituents. Starch preparations from corn; cooking to dextrin and to paste, hydrolysis to glucose.

Sugars: Preparation and refining of beet and cane varieties; conversion to caramel; inversion.

Fats: Olive oil, cotton seed oil, butter, oleomargarine, hardening oils by hydrogenation.

Proteins: Albumins, casein, gluten, peptones, gelatine, vitamines.

Beverages: Charged waters, soda, mineral, infusions, tea, coffee.

Fruit juices (artificial flavors), fermentation.

Poisons and common antidotes. Common inorganic drugs.

Leavening Agents: Yeast, soda, baking powders.

Matches: Ordinary and safety types.

Adhesives: Gums, paste, dextrin, glue, casein, water glass (sodium silicate).

Inks: Various types.

Refuse Disposal: Sewage, garbage; fermentation and putrefaction; civic problems; disinfectants and deodorizing agents.

Preserving: Sterilizing, pasteurizing, dessicating, pickling by salt and sugar; chemical preservatives and tests for them.

Metals: Extraction processes; oxide ore, iron, sulfide ore, lead; electrolysis, sodium and aluminum; extraction of other metals may be studied by comparison with these.

Metals: Used for basic purposes, iron, copper, aluminum, lead; for ornament, gold, silver, nickel; for alloys, bronze, brass, solder type metal, antifriction or bearing metals, fusible metal.

NORMAL UNIVERSITY HOMECOMING.

The Illinois State Normal University will hold its third annual homecoming, October 26 and 27, 1923. The principal features of the celebration will be: Friday 8 p. m., The Jester Play; Saturday 8 a. m., Stunts and Reunions, 12, Noon Luncheons, 2:30 p. m. Football, Blackburn College vs. Normal University, 8 p. m. Homecoming party.

For further details and reservations address Annette B. Cooper, Chairman, Normal, Illinois.

PRACTICAL PLANT PROTECTION.[1]

WILLIARD N. CLUTE,

Editor, American Botanist, Joliet.

In the early days the wild flowers were so abundant and widespread that the destruction of immense numbers was of no consequence, but with the growth of our country, many of the more showy and attractive specimens have been brought to the verge of extinction. A few species have disappeared or are disappearing from purely natural causes, such as the chestnut blight and the pine blister rust, but the greatest enemy of the plants is man. For every flower picked for a bouquet, he destroys thousands by felling the forest, flooding the valleys, draining the swamps, burning the thickets and tearing up the prairie sod to set a whole new race of plants in the place of violet and shooting-star, puccoon and camassia, phlox and gentian, sunflower and goldenrod. His cattle trample them, all sorts of animals feed on them, the mower lays countless thousands low, and yet in some way little short of a miracle another year finds them smiling from fence-row and thicket with the same trustful innocence as of yore. Only when he finally stakes out a factory village in the midst of all this loveliness do the native plants give up the struggle.

Such things have to be if our own race is to survive, but we may well object to all unnecessary destruction of our wild plants. The road-maker has no sooner torn his way through the wilderness than nature sets to work to repair the damage with a cloud of wildflowers. The ugly wounds of plow and scraper are healed with boneset, Joe-Pye-weed, clematis, bittersweet, asters, goldenrod and a host of others. And then back comes the road-maker to "improve" his work by removing all this loveliness. To him the birds, the wild-flowers, the sheltering trees and the wild things that scurry from one thicket to another are not to be compared to a carefully barbered roadside bordered by a neat barbed-wire fence. Law-making bodies often encourage him in his efforts to lay waste the countryside by requiring this annual slaughter of the wildflowers. Beauty is no excuse for being in the eyes of one who considers himself a practical man. In my own town sometime ago, the question arose as to whether a certain nook about one of the public buildings should be covered with

[1]Read at Galesburg meeting of Ill. Academy of Science.

concrete or set with plants, and the care-taker was ordered to do whichever was cheapest!

Of all offenders against good taste in such matters, the railroads are the worst. Though quick to see the advantage of planting the station grounds with beautiful flowers, they are blind to the fact that the selfsame species are doing their best to ornament the whole right of way, and they send out laborers to cut them down. Great clumps of lilies, acres of painted-cups, banks of anemones, swamps of wild hyacinth, clouds of phlox, thickets of laurel, sandy wastes blue with lupine and whole galaxies of sunflowers fall before this untutored savage with a scythe. In late August last year, I traveled more than a thousand miles on our mid-west railroads without seeing a single conspicuous patch of wild flowers on the right of way. The mower had done his worst. The poorer railroads through lack of funds may still allow some of these wildlings to grow, but the better roads mow them down and then dilate on the scenery through which they run.

Added to the other destructive agencies must be the vandal out for a day's holiday. He not only devastates the roadsides but invades private property as well. Much of his transgressions must be ascribed to ignorance, for the general public seldom considers flowers of any special value and, indeed, supposes them to grow out of the ground much as wool grows on a sheep and therefore to be picked without compunction. It is to this individual that the increasing rarity of the wild flowers in the vicinity of cities and large towns is mostly due and now that the automobile has widened the range of his activities, no part of the country is safe.

It has often been assumed hastily, that the methods of protection applied to birds so successfully need only be extended to the wild flowers to have equally happy results, but a moment's reflection will serve to show that the cases are far from identical. Birds being able to move about from place to place are rarely, if ever, in the way. They are peculiarly the property of the whole public and their collection may well be prohibited entirely. Unlike the flowers, their attractiveness departs with their collection. Moreover, gifted with movement, they can move out of harm's way and are less easily exterminated. Every person induced to cease hunting them gives them that much more chance of surviving, but with plants, so long as there is a single person collecting, all are in danger. It is also easier to make sentiment in favor of bird protection because birds are known to be helpful

as well as attractive in other ways. Birds may even be tolerated among our crops and attracted in various ways to frequent and nest in our grounds.

It may be doubted whether it is wise to prevent or even to discourage all picking of flowers. They appeal to the better natures of everybody, and children especially are not content to admire but must acquire as well. Childhood forbidden to gather flowers would be a sorry spectacle. All our traditions are in favor of making use of the flowers. Man wore flowers long before he wore clothes and he still takes pleasure in decorating his grounds, his residence and himself with them. The use of plants in garlands and coronels has been a custom for so long that this is embodied in the common names that were in existence long before scientific names were thought of. We still make use of a wealth of flowers on all festive occasions, and with them we also attempt to cheer the sick or soften the grief of those whose friends have passed on to more flowery fields. Every city and hamlet has one or more shops wherein are sold flowers only. In view of all this we cannot reasonably ask the lover of flowers to cease picking them entirely. There is a pleasure in the pursuit of anything that comes only with possession. Does anybody imagine that the hunting and fishing that still go on in settled communities is inspired by the need of food? Far from it. The spoils brought home by the hunter or fisher are simply the trophies that speak of his success. They are concrete evidence of his prowess. And shall we deny the child, the poet and other flower lovers their evidences of success? Why, even the birds gather flowers! The martins delight to deck their nesting sites with blossoms, and even the blood-thirsty hawk has been known to ornament his nest with violets.

Fortunately for us, all flowering plants do not need protection. The rough and ugly weeds need not be included in our list since nobody cares to collect them, but there are many fair flowers as well as weeds on the farmer's list of enemies, and many others whose room is regarded as much better than their company. A large number must be exterminated if we and our crops are to live. One may gather as much as he will of buttercups, daisies, toad-flax, evening primroses, bouncing Bet, rudbeckias, golden-rod, wild morning glories and the like without fear of reducing the supply. And there are many others so rampant as to growth, so ubiquitous and persistent, that an annual picking seems almost necessary to keep them within bounds. Of this nature are

dandelions, bouncing Bet, the elder and in some localities the wild crab. We may be thankful, also, that there are a few others that are protected by their habitat: species of inaccessible cliffs, remote mountain summits, desert fastnesses and extensive barrens. These are natural sanctuaries in which the embattled plants may persist long after their kind elsewhere have given up the contest. No thoughtless band of picknickers are likely to devastate such a region or destroy a whole race at one sweep.

The plants that are in need of special protection are a comparatively small number that have been brought to the attention of the public through some special attractiveness they possess. All the early flowering species are in danger because, coming so close on the heels of winter, they are typical harbingers of the milder season to which we always look forward. The flowers of midsummer rarely receive like attention. Then there is another class made conspicuous by history, tradition or use, such as the fringed gentian, ginseng, golden seal, pitcher plant, lotus, arbutus, the orchids and the like. Plants which are shallow-rooted and easily pulled up, like the phlox, hairbell and the cardinal flower, or those in which the leaves are collected with the flowers, such as trillium, jack-in-the-pulpit, rue anemone, are especially in need of protection. Unusually fragile species must also be considered, such as the dutchman's breeches, bloodroot, celadine, and Indian pipe. To these must be added those species whose leaves are the objects sought, among them the laurel, galax, many ferns, and ground pine. Last are those plants whose beauty is so conspicuous as to attract even the matter-of-fact business man—the azalia, the mountain laurel, water lilies, flowering dog-wood, redbud and others. All these must be protected or they will disappear speedily.

All right-thinking people are agreed that our wildflowers should be protected, but they are not of one mind as to the best way to accomplish it. The sentimentalist speaks of "the sanctity of plant life" and adjures us to "love the lily and leave it on its stalk" or perchance to" leave the dainty little recluse to fulfill the law of its being." If he (or is it she?) is speaking of properly protected areas, we may not object, but of what advantage is it to leave a much desired specimen to the tender mercies of the marauding urchin or some wandering cow? I still remember with some chagrin inducing a class on a field trip to refrain from gathering a thousand or more pogonia orchids, and later while lunching in a shady spot, seeing the entire thousand go by—a

solid mass of wilting blossoms in the clutches of a couple of small boys. So long as there is one individual interested in picking, no plant in unprotected areas is safe.

If we divest the whole question of sentiment and get down to the business methods of protecting plants, we shall discover that adequate laws, justly enforced, are the only solution of the matter. We should bend our energies toward securing a law in every state which will back up the land-owner in protecting his own. And after such a law is secured, we should see that it is enforced. The sale of wildflowers should be forbidden absolutely, except by legal permit, and the dealers in such things should be obliged to breed their stock and not dig it up from the wilds. With proper laws, sanctuaries for plants could be established and maintained. Every park, every large estate, the railroad rights of way, the lake shores, the river banks and many roadsides ought to be made sanctuaries of this kind. The railroads maintain with some truth that the undergrowth must be kept down to prevent disastrous fires, but it is quite possible to indicate the decorative plants and exempt them from the annual mowing. A number of interesting plants, owing to the special conditions under which they grow, must be protected probably, in their present habitats, but this in a majority of cases is entirely feasible. In other cases, rare plants may be removed to protected areas.

Even with adequate laws there is still needed an effort to interest land-owners in protection. Every farm woodlot should become a protected area until the land is needed for something else. It should be fairly easy to induce the farmer to post his entire farm and perhaps to design a special notice for the purpose. When his attention is drawn to the interest the botanist has in some rarity on his lands, he is generally as much in favor of protecting it as anybody.

It is probable that there will always be numerous areas in which flower picking may go on, but even here there is need for education in the selection of the flowers and in the proper manner of gathering. Emphasis should be laid on the fact that a few well-chosen blossoms are far superior to a larger number gathered with less discrimination. The ignorant and unthinking are ever impressed by mere size and reason that if a dozen are good, a hundred are better. It is a failing that all are prone to. Do we not always mention the size of our home town before mentioning its intellectual citizens? Children and adults, too, for that matter, should be taught to select only the fresh and newly-opened

specimens, leaving those that are past their prime to reproduce the plants. Merely to instruct the public in the proper way to gather flowers will go a long way toward protecting the landscape from devastation. The true lover of flowers rarely returns from an excursion laden with specimens. The planting of memorial trees and the decorating of our great trans-continental highways with flowering plants should do much to direct the attention of the public toward a right attitude regarding the wild flora.

But in the end we come back to our original thesis; the best and most practical way of protecting the plants is by adequate laws properly enforced. Let us do what we can to hasten the day when this condition shall prevail throughout the land.

STANDARDIZED TESTS.[1]

W. C. HAWTHORNE,

Crane Junior College, Chicago, Ill.

Tests or examination of some sort are a recognized part of the instruction in every serious course of study. If it is a standard course—one in which the same topics, essentially, are given to large numbers of classes, the tests in the different classes will necessarily be somewhat alike. If a test covers materials commonly given in all schools, and if we *know*, not merely guess, what the average student should do on such a test—better still, if we know what the best ten per cent will do, the next best ten per cent, and so on, we shall have a Standardized Test.

The preparation of a Standardized Test involves much more work than is given commonly to a set of ordinary examination questions. The subject matter of the test should cover not only what has just been studied, but what we may reasonably expect will be studied next year and every year in all schools. This will make a long examination, you may say. It is true, but not a long one for the pupil to answer, or for the teacher to score, as I shall show. Moreover, the Standardized Test parts company with the idea that any pupil shall answer all the questions. If the test is to be used in many different schools, in order to give every one a chance, it should contain from twenty-five to fifty questions, correct answers for sixty per cent of which may, perhaps, be regarded as a high score.

Such a test as this is scored easily, if the answers are very short. There are several types of questions admitting of such answers, and they need not be of the "yes or no" type either. First may

[1]Read at the Galesburg meeting of Illinois Academy of Science.

be placed numerical problems, and the pupil should have been trained to indicate the process by which the answer was obtained; not the literal formula, but one containing all the numerical data, with the operations indicated. Perhaps the pupil is called upon to indicate, by underscoring, which of several answers given is the correct one. Perhaps certain statements are given, to be checked as true, false or uncertain. I think the "true-false" test, and especially the usually recommended method of summing up the scores (i. e. rights minus wrongs) is about discredited. Not only may guessing play too large a part in the student's performance, but the subtraction of the number of "wrongs" from "rights" may leave him with a minus score. Moreover, it can be proved that the subtraction of all or any part of the wrong answers from the number of right ones leaves the examinee with exactly the same relative rank in the class as when the usual method is followed—counting up the correct answers only. But if a third type of statement be added, the truth or falsity of which it is impossible to determine from the data given, and if, moreover, both false and uncertain statements are so worded as to have a considerable air of plausibility, the possibility of getting a high score by guessing is probably no greater in this than in any other test. Still another type of easily scored question is that in which the one word which gives the correct meaning to a sentence is omitted. Considerable skill is needed here, if the missing word is not to be too obvious, on the one hand, or the meaning of the sentence, on the other hand, too obscure even to those well acquainted with the subject. It is obvious that the wording of questions must be such that teachers cannot disagree on the scoring of any question.

The arrangement of the questions will depend upon two points of view; whether we wish to test the student's quickness to recall and use facts which should be thoroughly known; or to determine his grasp of the subject, his power. If the former, we will make the questions in any set uniformly difficult and impose a sharp time limit, so that only the quickest will be able to finish; if the second, we will let the questions in each set increase sharply in difficulty, so that only those who have the greatest mental power will be able to answer all. Plenty of time should be allowed on this test, and in order that those who get through first shall not disturb the others, additional questions should be provided, the scores of which, however, should not be recorded with the others. At Crane Technical High School and Junior

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With a view to stimulating on the part of the public some appreciation of various phases of mathematical development, the American Mathematical Society has established an honorary lectureship. Under the auspices of the Society, some scientist of the highest distinction will be invited to deliver a semipopular address on a topic in mathematics or its applications. This lectureship is named for Josiah Willard Gibbs, whose fame sheds lustre not only on the Society but on American science in general.

It is proposed to have lectures at intervals of a year or more and it is expected that the first will be given in New York during the winter 1923-24.

College, we have now in preparation physics tests in sets of twenty-five questions, with as many alternative sets as possible, of which the high school pupils are expected to answer the first twenty, and the college students the whole number. Not infrequently the self complacency of some careless collegian has received a severe jolt, when we have shown him that his score on a certain test is less than that of the average high school boy.

We are now ready to give the test for the first time. It is evident that the usual precautions to prevent copying and communication are more necessary when the answers are as short as in this sort of a test. There should be a printed or mimeographed sheet of the questions for each student. Distribute them face downward, not to be looked at until the signal to begin is given. I have not been able to discover that it makes any difference, whether the answers are written on the same or another sheet of paper. If the questions are supposed to be of about equal difficulty, note the time of starting, and stop when the first few have finished. This gives an idea of the standard time to be fixed for the test.

Before scoring, prepare a key on a slip of stiff cardboard, with answers so placed that they correspond in position with the answers on the students' papers. If the test is answered by underlining words, or filling in blanks, the key may be made on a sheet of celluloid or transparent paper, or a cardboard with holes at the proper places to show the correct answers. With such devices as these, the drudgery of scoring the papers is reduced to a minimum, and it is very evident that more questions per test, and more tests per year, can be handled without adding to the already heavy burden of the conscientious teacher. Add to this the moral satisfaction of knowing that you have eliminated from your grade book the influence of the famous "sweet smile and winning way," and you will be willing to take the extra trouble necessary in preparing the tests.

Although in assigning values to correct answers, it is very easy, say, that students should be marked as right or wrong only, in practice it is often very difficult to do. Suppose a pupil has worked a problem by the right method, but because of a mistake in arithmetic, or a mistake in copying, he puts down the wrong answer. Should he not get some credit for it? Many questions, again, can not be properly answered but by the use of several words. Suppose the full answer is "Simple harmonic motion" and the student writes "Harmonic motion." It is neither com-

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pletely right nor completely wrong. It has therefore been my custom to give *two* for correct answers, *one* those partly right. Elaborate methods have been worked out for giving weighted scores, the values of which are proportional to the percentage of pupils failing on each question. It is doubtful if such a scheme is worth the trouble it takes. Better recast the whole test if there is any great difference in the difficulty of the questions.

Having scored the papers, we must next study them for certain necessary information. To find whether the test is too hard or too easy, we plot a curve, using the scores as abscissas, and the number of pupils making each score as ordinates. An approximation to the normal probability curve shows that we have a test reasonably suited to the capacity of our class; if it is skewed to the right, it is too easy; if to the left, it is too hard.

We may next study the relative difficulty of the questions by recording the number of times each question has been missed. If any question has been missed by no one, it is too easy and should be dropped. On the contrary, if any question is missed by all, it is too hard: the form is ambiguous, or the content is too difficult for their comprehension, or the subject has not been taught properly. It should be dropped or reshaped. If the number of correct answers to each question runs from ninety-five to five per cent, we may conclude that we have a good set.

The next step is to revise the questions, eliminating some, restating some, inserting others, and putting the harder questions toward the end. Another trial on the same or a similar class should be much more satisfactory; that is, it should give a normal distribution in which the failures should be much more numerous in the latter part of the test than in the first part.

We are now ready to compare the grades on this particular set of questions with a criterion. About the only one we have is the teacher's judgment, as derived from his knowledge of their laboratory work, their written reports, their daily recitations and the average of all their previous tests to date. If in general the best students have made the best scores and vice-versa—in other words, if there is a high correlation, say 0.6 or more between the class grades and the results of this test, we may conclude that we have a satisfactory test. Standardization may then proceed as fast as we can give the test to other classes in the same or other schools, accumulate and classify the scores, and establish norms.

What about the student's reaction to this type of tests? Uniformly satisfactory. They do not dread them; they are even

Advance Notes on Forthcoming Meeting of

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

at

Indianapolis, Ind.

NOVEMBER 30 and DECEMBER 1

For the first time in the history of the Central Association the annual meeting will be held in the Hoosier Capital, Shortridge High School of Indianapolis being the headquarters and, together with the Arsenal Technical Schools and the Emmerich Manual Training High School, the host.

If the season is normal fairly mild weather may be expected at that time and several trips in the out-of-doors have been planned for some of the sections. The Physics section will probably motor to Bloomington to hear and see an illustrated lecture by Prof. Arthur Foley of the Indiana University on Saturday afternoon, Dec. 1st. The Geography section and other members who may wish to accompany them will travel over the same road, but more leisurely, under the direction of the Professors from the Geology Dept. of the State University, stopping to examine some of the many interesting features of the very varied country between Indianapolis and Bloomington. This part of Indiana has many wild and rough places, some of them in the glaciated part of the state and others in the limestone and sandstone districts. Gold and diamonds have been found in the concentrates in the stream beds of the terminal moraine country through which the party will go and the limestone country is full of sink holes and caves. There are immense quarries for limestone and huge plants for dressing it which can be visited. Arrangements will be made so that those who wish to go on these trips may be accommodated in autos or busses at very reasonable rates. Definite notice will appear in the program of the Association soon to be mailed out. Reservations as per the program should be made.

A good general program is assured, one of the speakers being Dean A. A. Potter of the Purdue School of Engineering.

Splendid section meetings are assured. Indianapolis is easily reached via many railroad and trolley lines. Reduced rates will be granted over Central Assn. Passenger lines if 250 or more members secure certificates and get them validated at Indianapolis. Come and mix with some if the most progressive teachers of science and mathematics in the country! *Remember!*
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FRANK B. WADE, President.

SHORTRIDGE HIGH SCHOOL, INDIANAPOLIS

eager for them. It is amusing to see them "get set" and "go" after a few experiences, and settle down to a good natured race to get every word possible written in the ten or fifteen minutes before "time" is called. They feel that the larger number of questions gives them a better chance of telling what they know and there is never any chance for a difference of opinion as to what a certain answer is worth.

Finally, no claim is made that all the testing of a year's work can be done with this kind of tests. Even for the measurable results of our work, an occasional one or two hour test of the old type is desirable. And no scheme of "testing," no matter how perfected, should blind our eyes to the most important objectives of our work: the appreciation and love of science, the habit of mental honesty, and of deferring judgment until all available evidence is weighed carefully; in a word, that attitude of mind that will make of the raw material that comes to us, good citizens and reverent, obedient inhabitants of a Universe that is governed by law. These are things that can not be measured by an examination nor expressed by grades in a class-book.

PINCHOT URGES CONFERENCE ON WORLD RESOURCES.

An international conference on the natural resources of the world is urged by Gifford Pinchot, governor of Pennsylvania and conservation advocate, in the foreword to two volumes, "Forest Resources of the World," just published. This book, by Raphael Zon and William N. Sparhawk, was prepared by the United States Department of Agriculture, in cooperation with the National Research Council.

"Theodore Roosevelt, in the last days of his presidency, took steps to call an international conference for the purpose of preparing an inventory of the natural resources of the world," Gov. Pinchot writes. "Such a conference would be most timely now. It would not only bring together the known facts as to the extent and location of these resources, but could also outline general principles for their development and conservation. Forest resources naturally would be one of the principal subjects of consideration. Arrangements would be made for the uniform collection of statistics regarding forest areas, kinds and amounts of standing and growing timber, and production, consumption, and trade in forest products.

"Such a conference would be particularly valuable at the time when a great part of the world is out of adjustment, after an exhausting war, and is eagerly seeking means of creating the new economic relationships which are essential for its normal development. Access to raw materials on equal terms for all countries is one of the fundamental needs if peace is to be preserved and economic rivalries kept within bounds. An inventory of the natural resources of the world is indispensable for the formulation of any international policy for developing them for the benefit both of the world at large and of the individual nations within whose boundaries they lie."

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C. M. SHARP,
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The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS

791. *Proposed by Elmer Schuyler, Bay Ridge High School, Brooklyn, N. Y.*

Given x, y, a, b as integers in the equations

$$(1)\ x^2+y = a, \quad (2)\ x+y^2 = b,$$

what relation must exist between a and b so that a solution is possible? Show that there can not be two solutions for a given pair of values for a and b.

Solution by J. F. Howard, Brackenridge High School, San Antonio, Texas.

Multiplying (2) by x and subtracting from (1) gives

$$xy^2-y = bx-a, \text{ or } y = [1 \pm \sqrt{1+4x(bx-a)}]/2x.$$

If y is an integer, then the radicand must be a perfect square, or $b = a^2$.

Again, multiplying (2) by 2, and adding to the equation $xy^2-y = bx-a$, gives

$$(x+2)y^2-y = bx+2b-a-2x.$$

Solving this equation for y, and imposing the condition that the radicand must be a perfect square, gives $a^2+18 = 8a+b$. Hence this relation or the previous one, $b = a^2$, will give integral solutions for x and y, but we have not proved that either of these conditions is *necessary*.

To show that there can not be two integral solutions for a given pair of values of a and b, let x_1, y_1 and x_2, y_2 be the solutions. Then

$$\begin{aligned} x_1^2+y_1 &= a & \qquad x_1+y_1^2 &= b \\ x_2^2+y_2 &= a & \qquad x_2+y_2^2 &= b \\ x_1^2-x_2^2+y_1-y_2 &= o & \qquad x_1-x_2+y_1^2-y_2^2 &= o \\ \frac{y_1-y_2}{x_1-x_2} &= -(x_1+x_2) & \qquad \frac{y_1-y_2}{x_1-x_2} &= \frac{-1}{y_1+y_2} \end{aligned}$$

$$\therefore\ x_1+x_2 = \frac{1}{y_1+y_2}$$

which is impossible if x_1, x_2, y_1, y_2 are integers.

792. *Proposed by Paul Ligda, Oakland, California.*

Mail arrives at a uniform rate during the day. To dispose of thi mail and of the mail accumulated before business hours the practice was to put the entire force of 22 clerks to work at the beginning of the working day, the job being finished in 20 minutes. The number of clerks was reduced to 12. These would catch up with the work in one hour. As it is desired to reduce the office force still further, the manager wishes to know 1—How many clerks would be needed to catch up with the incoming mail in 5 hours. 2—How many clerks would be needed to keep up with the incoming mail the rest of the day.

Solution by Albert J. Dow, Harvard Graduate School of Education.

Let x = the number of hours it takes one man to handle the old or accumulated work.

Let y = the number of hours it takes one man to handle the new work which arrives each hour.

Then $x/22+\frac{1}{3}y/22 = \frac{1}{5}$ and $x/12+y/12 = 1$.

From these equations we find $x = 5$, $y = 7$.

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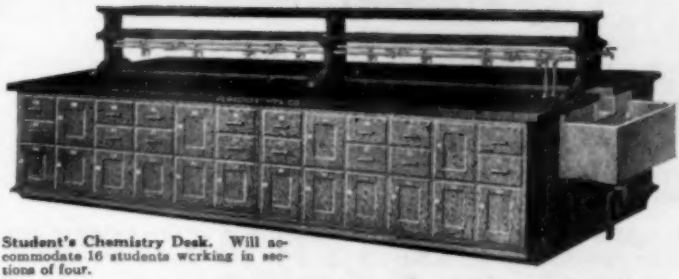

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If, now, k = the number of clerks in question 1, and g = the number of clerks in question 2, then

$$5/k+35/k = 1 \text{ and } 7/g = 1.$$

Hence $k = 8$ and $g = 7$.

Solution by Michael Goldberg, Philadelphia, Pa.

Let x be the number of clerks needed to keep up with the incoming mail.

Then $(22=x) = 3(12-x)$ since $(22-x)$ clerks dispose of the accumulated mail in one third the time that $(12-x)$ clerks used. Hence $x = 7$.

Since $(12-7)$ clerks dispose of the accumulated mail in one hour, one clerk could do it in 5 hours. And $(1+7)$ or 8 clerks would be needed to keep up with the work during the rest of the day.

Also solved by *Thomas E. N. Eaton, Redlands, California; J. F. Howard, San Antonio, Texas; W. W. Wallace, Sacramento Junior College, Sacramento, California.*

793. *Proposed by J. K. Elwood, Philipsburg, Montana.*

From a point C two tangents CA and CB are drawn to a circle. CA = CB = 1/4 mile. The major arc AB = 1/2 mile. Find the size of $\angle ACB$.

Solution by Daniel Kreth, Wellman, Iowa.

If $\angle AOC = x$, then the radius of the circle = $\frac{1}{4}\cot x$, and the major arc $AB = 2\pi \times \frac{1}{4}\cot x \times (360-2x)/360 = \frac{1}{2}$.

This equation can be written.

$$180 \tan x - \pi(180-x) = o$$

By trial we find x is about 64°. Substitution of this value of x in the equation, gives an error 4.628.

If we then substitute $x = 63° 45'$, we find an error of $-.207$. Hence

$$(4.628+.207) : 15' = .207 : \text{correction}$$

and the correction is therefore .641′ or 38.5″.

Proceeding as before we find $x = 63° 45' 40''$.

Hence $\angle ACO = 26° 14' 20''$ and $\angle ACB = 52° 28' 40''$.

Also solved by *J. F. Howard.*

794. *Proposed by J. F. Howard, Brackenridge High School, San Antonio, Texas.*

Given three points A, C, B in a plane. Find the locus of P if $PA^2+PB^2+PC^2$ is constant.

Solution by W. W. Wallace, Sacramento Junior College, Sacramento, California.

Take for the axes of coordinates the line through A and B, and a line through A perpendicular to AB. Then the coordinates of A, B, and C are respectively A (o, o), B (a, o), C (b, c).

By the conditions of the problem

$$x^2+y^2+(x-b)^2+(y-c)^2+(x-a)^2+y^2 = k^2$$

where (x, y) are the coordinates of the point P.

This equation can be written

$$x^2+y^2-2x(a+b)/3-2cy/3 = K^2$$

which represents a circle whose center is $[(a+b)/3, c/3]$ and this point is also the centroid of the triangle ABC. The radius depends upon the value of the given constant.

Using three dimensional coordinates, *Howard D. Grossman, Brooklyn, N. Y.*, and *Michael Goldberg, Philadelphia, Pa.*, showed that the locus is a sphere whose center is the centriod of the $\triangle ABC$. *F. A. Cadwell, St. Paul, Minnesota,* also gave a very fine solution and discussion without the use of coordinates. Also solved by the proposer.

795. *For high school pupils. Proposed by J. K. Ellwood, Superintendent of Schools, Philipsburg, Mont.*

What price can a buyer afford to pay for a \$100 4 1/2 per cent bond having 10 years to run, interest payable semi-annually, in order that he may realize 6 per cent per annum, payable semi-annually?

No solution of this problem have been received although several teachers have inquired whether the pupil is expected to consider simple or compound interest. The proposer indicated that some such solution as the following might be expected

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The semi-annual interest is \$2.25, which is 3 per cent of \$75. Hence \$75 is the price to be paid if only that sum is to be paid the buyer when the bond matures. But \$100 will be paid; hence the buyer gets \$25 besides his interest.

Since the buyer has to wait 10 years for this \$25, we must find its *present value* at 3 per cent semi-annual compound interest; that is, we must find what sum paid by the purchaser *now* (or added to the price of the bond) will amount to \$25 in 10 years.

The compound amount of \$1 at 3 per cent for 20 periods is \$1,806.11.

The present value of \$25 is then $25 \div 1.80611$ or \$13.84.

Hence the required price of the bond is \$75+\$13.84, or \$88.84.

The editor has occasionally assigned such problems to the class doing the second course (or third semester) in algebra as they furnish a very useful application of both geometrical progressions and logarithms. Few pupils, however, can do the work well.

PROBLEMS FOR SOLUTION.

806. *Anonymous.*

A careless student wrote: $\sin (12°)^2 = \sin^2 144°$, which is not true. If he had written: $(\sin 80°)^2 = \sin^2 6400°$, it would have been true. Find positive integral values of x less than 90 for which the square of the sine of x degrees is equal to the square of sine of x^2 degrees.

807. *Proposed by Michael Goldberg, Philadelphia, Pa.*

Prove that $\tan\frac{2\pi}{7} \tan\frac{4\pi}{7} \tan\frac{6\pi}{7} = \sqrt{7}$.

808. *Proposed by F. F. Howard, San Antonio, Texas.*

Inscribe a square in a given quadrilateral.

809. *Proposed by James Singer, Ithaca, New York.*

Given $\triangle ABC$ and a point P within it. From the vertices A B and C draw lines AM, BN, CL through P and terminated by the sides of the triangle. AB produced meets NM produced in a point X; similarly BC and LN intersect at Z and AC and LM intersect in Y.

Prove that the points X, Y, and Z are collinear.

810. *For High School Pupils.*

The altitudes BE and AD of $\triangle ABC$ intersect at F. The two perpendicular bisects of AC and BC intersect at G. H is the mid point of BC and I the mid point of AC.

Prove that BF = 2 times GI.

SCIENCE QUESTIONS.

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Question for solution.

425. *"Saturday Evening Post" Science.*

(The following extract was taken from page 22, April 28, 1923, Saturday Evening Post.)

What do you think of this as science?

"The elastic limit of any material is the measure of its ability to recover its original shape after stresses applied have deformed it."

426. *Proposed by S. G. Rich, New York University.*

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opened, it is found that the cream has become considerably harder than that found in fresh tubes of the same make. What has caused the change? The tube is the usual lead tube, impervious to water, and is not damaged in any way. Is this a case of (**a**) hydrolysis from the water in the shaving cream, (**b**) absorption of some one component by some other; (**c**) separation of an emulsion into its constituents, or (**d**) a combination of these with possibly some other factors?

Examination Paper from E. W. Neuzil, St. Ambrose College, Davenport, Iowa.

(In the original paper spaces were left after each question in which the pupil wrote his answers.)

HIGH SCHOOL PHYSICS EXAMINATION

Time—2 1-2 *Hours.*

NAME

1. (a) Which is hotter: a bucket of water at body temperature, or a thimbleful of boiling water?

(b) Which contains the most heat?

(c) How much heat is required to bring a thimbleful (3cc.) of ice water to the boiling point? . . . How much to bring a bucket (8 liters) of ice water to the body temperature? . . .

2. (a) Will a cake of ice wrapped in several folds of a woolen blanket melt as rapidly as if unwrapped? . . . Why? . . .

(b) Is it, therefore, advantageous to wrap the ice of a refrigerator in a blanket? . . . Why? . . .

3. (a) Will water at 100°C. be liquid or vapor (steam)? . . .

(b) What is the qualitative and quantitative difference between a gram of liquid water and a gram of steam, both at the same temp. ans. . . .

4. Trace the heat from the fire under the boiler to a person in a steam heated room, by naming *in order* each thing the heat is transferred *through*, and the *process* or *mode* of transference through each. Ans. . . .

5. (a) What is lightning and what causes it?

(b) If the thunder comes six seconds after the flash, how far away is it? Ans.

6. (a) Describe the construction and operation of a door bell, and draw the wiring diagram.

(b) Draw diagram and explain operation of telephone receiver.

7. (a) What is the cause or source of sound?

(b) How fast does sound travel?

8. How does the phonograph record, and reproduce sounds?

9. (a) How fast does light travel?

(b) Does it always travel in straight lines?

10. Draw diagram of the photographic camera, name the essential parts, and explain the purpose of each.

11. (a) Of what is the positive plate of a lead storage cell made?

(b) Of what is the negative plate of a lead storage cell made?

(c) What is the liquid?

(d) What chemical change takes place as the cell is discharged?

12. An electric lamp takes 1.5 amps. at 110 volts. How much per hour does it cost to operate, at 9c per kilowatt-hour for electricity? Ans.

13. (a) What is the combined resistance of 8 conductors in parallel if each is 220 Ohms? Ans.

(b) What current will flow through each at 110 volts? Ans.

14. What are two advantages of the high heat of vaporization of water? Ans.

15. If the specific heat of iron is 0.1125, how much ice at O°C. can be melted by 200 gm. of iron at 300°C?

16. What is the difference between a noise and a musical sound?

17. How many calories are produced per second by an electric toaster that uses 5 amps at 110 volts?

18. Why is perpetual motion impossible?

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CAMBASCO NEWS.

There has recently come to our desk a copy of the Cambasco News which is gotten out by the Cambridge Botanical Supply Co. at Waverly, Mass. The little pamphlet contains many things that are new with reference to apparatus. I am sure that all science teachers would be benefited materially if they would get in touch with the publishers of this little pamphlet and have it put on their mailing list.

There are many new things in it: for instance, "Mercury may be freed of its grosser substances and grow sufficient for laboratory work by filtering through ordinary sugar." There are many other things of like character contained in the pamphlet.

I would like to see books of this type put out by progressive science houses.

C. H. S.

SCIENTISTS OF WORLD ALLIED AGAINST INSECTS.

Entomologists throughout the world are working together in the war against crop insects, according to Dr. L. O. Howard, chief of the Bureau of Entomology of the United States Department of Agriculture. Parasites which prey upon damaging insects and keep their numbers down in one country are constantly being drafted by the scientists for use in the fight against the imported pests of another country.

Many of the insects which have found their way into this country from other lands, left their natural enemies behind them. In consequence, they have been able to increase in greater numbers than at home with greater damage to plant life they infest. In order to restore the balance of Nature, the entomologists study the life and habits of the insects in its own home land. They discover what parasites prey upon it and keep its number down. Some of these parasites are then collected and brought to this country to help check the ravages on crops here.

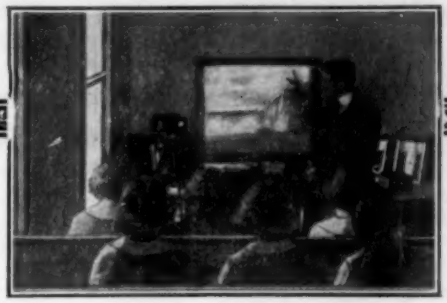
The United States now has an expert in Mexico in search of parasites of the Mexican bean beetle. Another is studying the enemies of the threatening Mexican fruit fly in that country. Two are in Japan seeking parasites of the Japanese beetle, while another is in that country looking for enemies of the gypsy moth, which continued to destroy trees in New England. Two men are just back from Hungary, where they also studied the gypsy moth whose native range is all the way from Europe across Siberia to Japan. But nowhere is it so damaging as in America.

Europe has furnished America more of the undesirable insect immigrants than any other section of the world, and the United States now has a complete laboratory with three experts at Heyeres, seventy miles east of Marseilles, France, for the study of the pests native to southern Europe.

Besides these American experts in the field, eutomologists of the various nations are in constant communication and frequently make collections of parasites for each other. Generally such exchanges are from the older to the newer countries but America has given effective help of this kind to Europe, notably in the case of parasites of the woolly root louse of the apple. This insect is a native of America, and until the parasites were supplied from here, it was doing great damage in France.

BOOKS RECEIVED.

Chemistry Applied to Home and Commerce, text book and laboratory manual, by Pauline G. Beery. Pennsylvania State College. Pages XVI+534. 15x21 Cm. Cloth. 1923. J. B. Lippincott, Philadelphia, Pa.



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Chemistry and Every Day Life, with manual by Charles G. Cook, Boys' High School, New York City. Pages VIII+454. 13x19 cm. Cloth. 1923. D. Appleton & Co,, New York.

Chemistry of Common Things, by Raymond B. Brownlee, Stuyvesant High School; Robert W. Fuller, Stuyvesant High School; William Hancock, Erasmus Hall High School; Jessie E. Whitsit, De Witt Clinton High School, New York City. Pages VII+616. 13½x19½ cm. Cloth. 1914. Allyn and Bacon, Chicago, Ill.

Psychology of Algebra, by Edward L. Thorndike, Margarite F. Cobb. Jacob S. Orleans, Percival M. Symonds, Elva Wald, Ella Woodyard, Teachers College, Columbia. Pages to 483.

First Text in Algebra, by Howard B. Baker, Lincoln High School, Jersey City. New Jersey. Pages IX+298. 13x19 cm. Cloth. 1923. D. Appleton & Co. New York City.

Mathematical Theory of Finance, by C. M. Putmum, University of California. Pages IX+117. 13½x21 cm. Cloth. 1923. $1.75. John Wiley & Son, New York City.

Subject Projects for Beginners, by Katherine Y. McLaughlin, University of California and Eleanor Troxell, Normal College, Dillon, Montana. Pages XIV+110. 12½x19½ cm. Cloth. 1923. $1.60. J. B. Lippincott Co. Chicago, Ill.

Algebras and their Arithmetics, by Leonard E. Dickson, University of Chicago, Pages XII+241. 13x19 cm. Cloth. 1923. $2.35. University of Chicago Press.

Modern High School Algebra, by Webster Wells and Wilter W. Hart, University of Wisconsin. Pages X+466. 12½x18 cm. Cloth. 1923. D. Appleton Co., Chicago, Ill.

Geography of Indiana, by Stephen S. Visher, Indiana University. Pages VIII+225. 13x19 cm. Cloth. 1923. D. Appleton Co. Chicago, Ill.

Social and Industrial studies for Elementary Schools, by Jane B. Welling, Normal School, Kalamazoo. Charlotte Calkins, Grand Rapids, Michigan. Pages ILII+331. 13x19½ cm. Cloth. 1923.

Vocational Education in Farming Occupations. Theodore H. Eaton. Cornell University. 374 pages—13x19½ cm. Cloth. 1923. $2.00. J. B. Lippincott Co., Chicago, Ill.

Health, Public and Personal. Ralph E. Blount Weller High School, Chicago, Ill. Pages X+316. 13x19 cm. Cloth. 1923 Allyn and Bacon, Chicago, Ill.

Problems, Projects and Exercises in Biology, by William H. Atwood, Milwaukee State Nornal School. Pages VIII+106. 13½x20 cm. Cloth. 1923. $0.96. P. Blakiston's Sons and Co., Philadelphia, Pa.

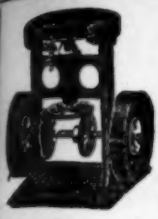
Elementary Chemical Calculations, by Martin Meyer. Pages VII +131. 13x19 cm. Cloth. 1923. Oxford Book Company, New York.

Comparative Vertebrate Dissection, by William H. Atwood, Milwaukee State Normal School. Pages IX+248. 14x20½ cm. Cloth. 1923. $2.25. B. Blackston's Sons & Co. Philadelphia, Pa.

Engineering Mathematics with Tables, by Miles E. Keasey, Alfred Kline, and D. A. McIlhatter, Drexal institute. Pages VIII+342. 16x24 cm. Cloth. 1923. B. Blackston's Sons & Co., $3.50.

How to Experiment in Education, by William A. McCall, Teachers College, New York City. Pages XIV+281. 14x20½ cm. Cloth. 1923. MacMillan Co., New York City.

Elementary Principles of Economics, by Richard T. Ely, University of Wisconsin. Pages XII+532. 13x19½ cm. Cloth. 1923. MacMillan Co.



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Laboratory Directions in Inorganic Chemistry, by Lexington Silverman, University of Pittsburgh. Pages IX+56. 20½x26½ cm. Paper. 1923. $1.25. D. Van Ostrand Company, New York.

Chemical Calculations, by R. Harmon Ashley, Tufts College. Pages XI+276. 13x19 cm. Cloth, 1923. $3.00 net. D. Van Ostrand Company New York.

BOOK REVIEWS.

Industrial Arts for Elementary Schools, by Frederick G. Bonser and Lois C. Mossman. Teachers' College, Columbia University. Pages XI 491. Cloth, 1923.

This book is divided in to two parts: Principles of Selection and Organization of seventy-five pages, and Principles of Subjects, suggested of four hundred ten pages. It is a book that is somewhat new in character. It is one that will prove of considerable interest to those people who are endeavoring to teach any form of the industrial arts in the elementary schools. It is profusely illustrated with very apt drawings, there being no less than 278 cuts, all being selected for the lesson they are intended to teach or illustrate. The work is easily adapted to the conditions of teaching, in either rural or city schools. Primarily it is prepared for teachers; yet it contains material which may be profitably used by children. It is printed in splendid ten point type. It shows work of careful editing, the major paragraphs being in bold face type and the chapters, of which there are thirteen, close with a bibliography of the material mentioned in that chapter. This book should be in the hands of every one in any way interested in the development of industrial arts.

C. H. S.

Elementary Chemical Calculations, by Martin Meyer, Ph. D., Instructor in Chemistry, College of the City of New York. First edition pp. VII plus 131; size 1¼x13x19¼ cm. Cloth. 1923. Oxford Book Company, N. Y.

A most excellent little book, presenting in the clearest possible manner the essentials of chemical arithmetic. The orderly progression is notable. The exposition is brief, but complete, and examples are given after each new step has been presented. Then follow many problems from which the teacher can select and assign a suitable number. The chapter headings will give an idea of the scope of the book. I. Units of measurement. II. Formulae and Molecular Weights. III. Percentage Composition. IV. Calculation of Chemical Formulae. V. Equations; weights from equations. VI. Volumes of Gases. VII. Weights of gases. VIII. Volume of gases from equations. IX. Solutions. X. Experimental Determinations of Molecular Weights. XI. Atomic weights and analytical calculations. XII. Ionization. XIII. Electrochemical problems. XIV. Special Cases. There follows an appendix, with atomic WT table, four-place log table, temperature conversion tables, vapor tension table for water and the metric system.

F. B. W.

Economic Geography of Indiana, by Stephen S. Visher, University of Indiana. Pages IX+225. 13x19 cm. Cloth. 1923. D. Appleton Co., New York City.

This is a remarkably interesting book, especially for the inhabitants of Indiana, although others interested in geography and geology will be interested in this splendid physiographic description of this particular state. It is written by one having authority and understands the matter thoroughly. The book is written in a most interesting manner. The

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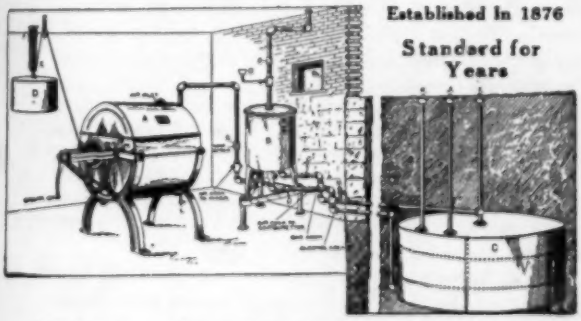

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diction is splendid. It is divided into fourteen chapters. The major paragraphs begin with bold face type giving the principal phase of the topic treated in that paragraph. They also give the key to the subject matter discussed in these paragraphs. The author goes into considerable detail in discussing the prominent features of the state. There are many tables scattered throughout the work. The book contains a very complete index. The mechanical work is as nearly perfect as can be. It is a book that should be used in every school in the state and it merits a wide circulation. C. H. S.

Elementary Principles of Economics by Richard D. Ely, University of Wisconsin. Pages XIII+532. 13½x19½ cm. Cloth. 1923. Macmillan Co. New York City.

This book is in its third edition. It is divided into four books and discusses many phases of economics. This edition remains practically the same as far as treatment of various subjects is concerned. Many chapters almost entirely so. An attempt has been made to improve the phraseology over former editions thus simplifying expressions. It has been brought down to date.

It discusses questions for the public mind as far as economics are concerned. Practically every chapter closes with a summary, questions for study and discussion on the points brought out in that chapter as well as giving a bibliography. It contains a list of biographical and historical subjects for essay and writing work and a very long bibliography of twelve pages is given as a final appendix. Mechanically the book is well constructed, printed on paper that is only partly calendered, in the usual ten point type and is a text which every one interested in economics should get and read. C. H. S.

How to Experiment in the Education, by Elmer A. McCall, Teachers' College, Columbia University, New York City. Pages XIV+281. 14½x20½ cm. Cloth, 1923. Macmillan Co., N. Y.

It is a habit now-a-days for many teachers to experiment with their classes on the methods of teaching. The experimenter knowing very little about the accomplishment of the task, and because of his work the results are very unsatisfactory indeed, not only to the teacher but to the pupil; whereas if the same teachers had first familiarized themselves with the best methods of this experimental work they would have made fewer mistakes and their results would be more satisfactory and worth while in every respect. They should have been familiar with some such work as this text as it stands as a classic in this kind of work, being written by an author who is perfectly familiar with that which he is writing about.

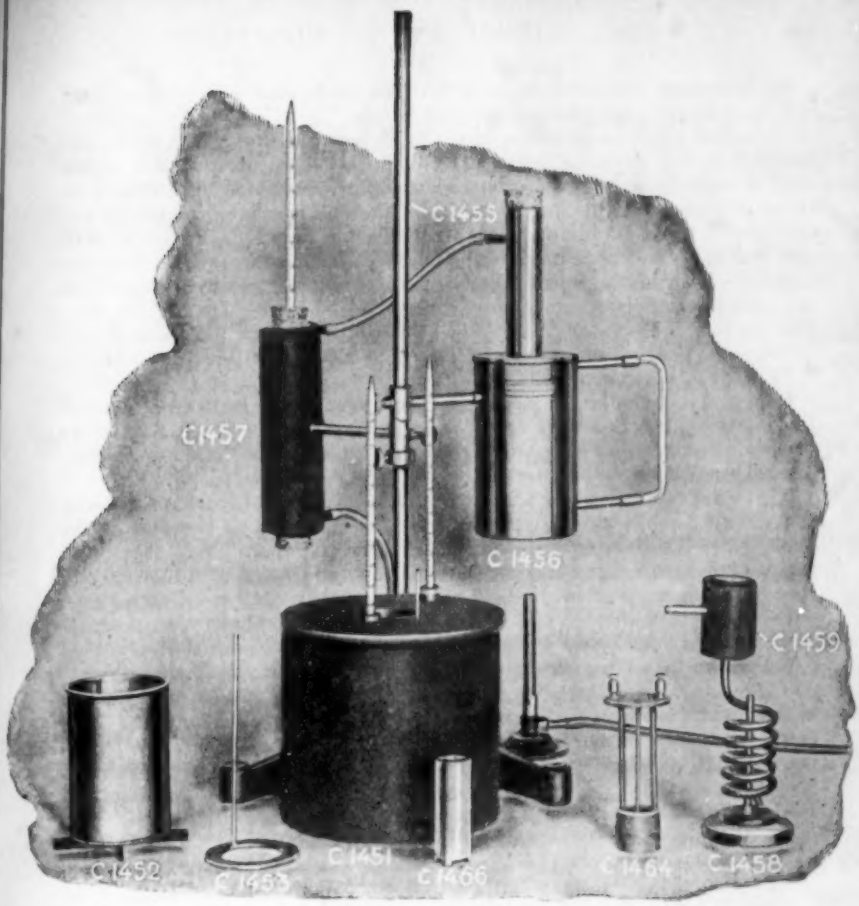
It is divided into ten chapters, there being included forty-eight kinds of tables. The diction is perfect, the statements true.

It is printed in rather heavy ten-point type on uncalendered paper. There is a long list of references to kindred work. It is completely indexed and is a book that all teachers interested in their work should be familiar with. C. H. S.

Vocational Education in Farming Occupations, by Theodore H. Eaton, Cornell University. 374 pages. 13½x20 cm. Cloth, 1923. J. P. Lippincott Co.

This is a book for which there has been considerable demand the last few years. We are glad that the author has seen fit to put into shape his views concerning the matter that is in the title of the book.

Without doubt, teachers of agriculture and kindred subjects have been at a loss to know just what to say to the inquiring student when he has come to him for information, not only for what he should study, but for his life work.



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There are fourteen chapters in the book, each one of which is as important as any of the others. The book is splendidly written, shows careful editing, every page contains the finest kind of information to those interested in this line of work. The book is printed on paper not calendered, thus avoiding the glare of reflected light. It is easy to read and study. The major paragraphs begin with bold face type. It is not indexed. This is a serious fault, but it does not in any way deduct from the quality of the work contained therein. C. H. S.

Physics for the Secondary Schools by Frederick E. Sersers, St. Paul School, Concord, New Hampshire. Pages X+658. 14x19½ cm. Cloth, 1923. F. M. Ambrose Co., New York.

Of the making of books in physics there apparently is no end. One of the latest of these books is one we are writing about. First of all there was no great need for this book, good as it may be, as there are already several good ones on the market.

This book considers physics in the usual order except, perhaps, placing sound and light before electricity, which is discussed at the end of the book. The illustrations are profuse, being no less than 522 of them, and many of the drawings and half tones are in the original. The writer of this review is very much pleased with the quality of these illustrations. The book is well written and as far as the writer is able to see the statements are correct. One great feature is the great number of practical problems and questions scattered throughout the text.

There are no mathematics but what the average Junior or Senior in high school can master. There is rather more material than can be covered in any one year. This is a good fault, however, because it leaves the instructor with the privilege of selecting the material which he thinks best to use. The last few pages of the book take up the discussion of Radio. It is a text that will undoubtedly have a large circulation. It is printed in ten-point type on paper not highly calendered. C. H. S.

Farm Woodlands, by James B. Berry, United States Forest Service. Pages VI+423. 14x19½ cm. Cloth, 1923. $2. World's Book Co., N. Y. C.

Farm Woodlands is a new style of book that has recently come from the press. Without question there is a great need for a book of this character. It surely will greatly assist in stopping wanton waste of timber in this country. With all the facts before us it seems incredible that men in this day and age would still persist in the wasteful use of timber.

A trip by the writer, in the northern part of Wisconsin and Michigan convinced him that strenuous measures ought to be taken to prevent the turning of trees seven or eight inches in diameter into paper pulp. He saw thousands of cords of logs, six inches in diameter, ready to be turned into pulp, whereas if they had been allowed to stand for a few years they would have obtained a growth sufficiently large to really warrant their change into paper.

This book covers almost every phase of the subject. It discusses the utilization of wasteland for the production of timber and fuel. It tells how timber may be used to prevent erosion of the ground where timber has been entirely wiped out. It discusses the kind of timber that will best grow in certain soils. The book is written primarily for agriculture schools but it will make interesting reading for ordinary laymen. There are 163 cuts and half-tones, all well selected for the lessons they are to teach. Typographically it is perfect. It is well bound and will stand hard usage. The writer advises every person, teacher or laymen, interested in this phase of work to secure a copy. C. H. S.